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Risk analysis for acute oroantral communication: a retrospective study

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ABSTRACT

Aims: The purpose of this study was to evaluate the relationship to type of sinus pneumatization with the relationship between extracted tooth and maxillary sinus in patients who developed oroantral communication (OAC).

Methods: The patients who developed OAC after maxillary extraction and underwent OAC treatment were included in the study. The predictor variable was the type of maxillary sinus pneumatization (MSP). The primary outcome was relationship between extracted tooth and maxillary sinus. The covariates were age and sex. A Kruskal-Wallis and Pearson chi-square tests were used for the statistically analysis.

Results: The study completed with 429 patients who met inclusion criteria. There was a statistically significant difference in the mean age between the relationship type between the extracted teeth and the maxillary sinus groups in this study ($p<0.001$). The highest mean age was found in type 2 (43.17±13.99), and the lowest was found in type 4 (36.26±12.79). In this study, type C MSP had the highest rate. In 46.03% of them, 1/3 of the roots of the extracted tooth were in the maxillary sinus. After type C, the highest rate was type E. More than half of the roots of 56.96% of them was in the maxillary sinus. There was a statistically significant relationship to MSP with type of relation between the extracted teeth and maxillary sinus ($p<0.001$).

Conclusion: The risk of developing OAC during the extraction of molar increases in young patients where the maxillary sinus dropped in the entire posterior or its borders cannot be distinguished.

Keywords: Oroantral communication, oroantral fistula, maxillary sinus, molar teeth

INTRODUCTION

Maxillary posterior tooth extraction is one of the most common procedures in dentistry practice. Sometimes it can cause an oroantral communications (OAC). OAC is relationship between the oral cavity and the maxillary sinus which is unnatural. If OAC were not treated can act as a pathway for bacteria to enter the maxillary sinus, causing infections, sinusitis, or and oroantral fistula. Thus, evaluation of risk factors is important to avoid occurrence OAC. The risk factors associated with OAC was analyzed in a few studies in past. The distance between the impacted upper third molar to maxillary sinus floor (MSF) was associated the risk of OAC occurrence.[1,2] Iwata et al.[3] evaluated the role of computed tomography scan predicting development of OAC. Archer et al.[4] classified the location of the impacted upper third molar. However, the usage of this classification for determining risk of OAC occurrence is controversial. Because this was mainly based on its spatial relationship with the second molar. Hasegawa et al.[5] evaluated the risk factors associated with OAC during extraction of impacted upper third molar. The focus of the past studies has generally been the impacted third molar. But the extraction of first and second molar are most frequent in daily practice. There are limited studies evaluating the relationship between MSF and posterior maxillary tooth. Explaining the relationships between MSF and maxillary molar roots is critical in preventing complications.[6] In this study, it was aimed to evaluate the relationship between the root of the extracted tooth and different type of maxillary sinus pneumatization (MSP) in patients who developed OAC during the extraction of maxillary posterior teeth.

METHODS

The study was designed as a retrospective cohort study on patients who applied to department of oral and maxillofacial surgery between 2012 and 2023 due to maxillary canine, premolar, and molar tooth extraction. The Clinical Researches Ethics Committee of Erciyes University Faculty of Medicine (Date: 29.03.2023, Decision No: 2023-204) approved the study. This study was conducted in accordance with the 2008 Declaration of Helsinki. The patients who developed OAC after maxillary premolar and molar extraction had pre-operative panoramic radiographs and underwent OAC relationship therapy were included in the study. Patients with congenital

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syndrome and incomplete records who had previously been operated on because of a tumor or trauma were excluded from the study.

Study Variables

The primary predictor variable was the type of MSP. Root Sinus classification of Hasegawa et al.[5] was modified to classify MSP. The primary outcome was relationship between extracted tooth and maxillary sinus. The covariates were age, sex and extracted teeth.

Radiographic Evaluation

All panoramic radiographs were taken with the same device (OP200 D; Instrumentation Dental, Tuusula, Finland; 66-85 kVp, 10-16 mA, 14.1-s exposure time) as the Frankfort horizontal plane was adjusted parallel to the floor and the sagittal plane for standardization. All evaluations were carried out by the same investigator. Type of MSP was classified on the preoperative panoramic radiograph as below:

Type A: Maxillary sinus without dropping (Figure 1a).

Type B: The maxillary sinus dropped only in extracted teeth area (Figure 1b).

Type C: The maxillary sinus dropped in posterior maxillary area (Figure 1c).

Type D: MSF follows the roots (Figure 1d).

Type E: The maxillary sinus drops over the roots, but its borders are not clear (Figure 1e).

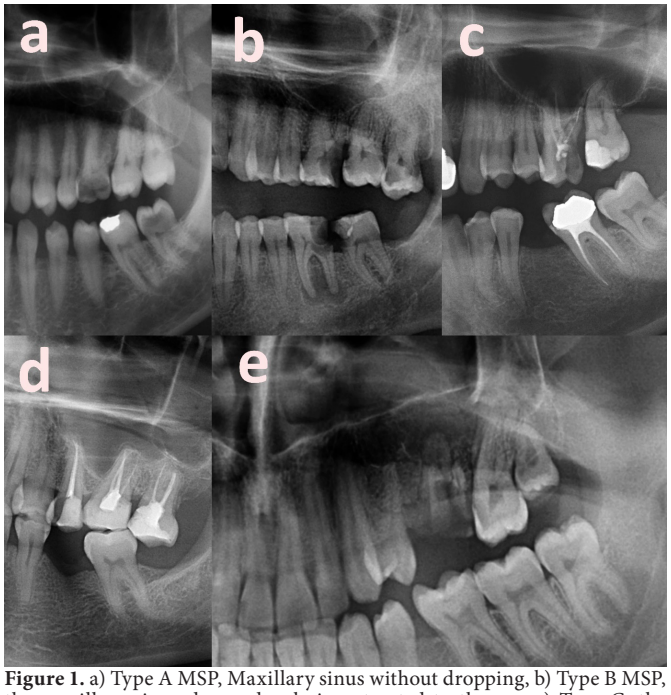

Figure 1. a) Type A MSP, Maxillary sinus without dropping, b) Type B MSP, the maxillary sinus dropped only in extracted teeth area, c) Type C, the maxillary sinus dropped in posterior maxillary area, d) Type D MSP, MSF follows the roots, e) Type E MSP, the maxillary sinus drops over the roots, but its borders are not clear

The relationship the roots of the extracted tooth with the maxillary sinus was evaluated as below:

Type 1: No contact between MSF and root of extracted tooth (Figure 2a).

Type 2: The apex of the root was in contact with the MSF (Figure 2b).

Type 3: 1/3 of the root inside of the maxillary sinus (Figure 2c).

Type 4: More than half of the root inside of the maxillary sinus (Figure 2d).

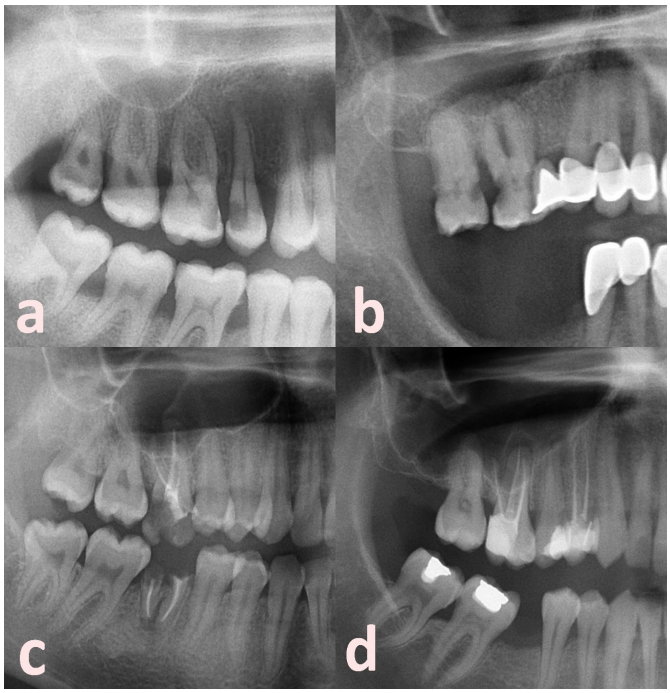

Figure 2. a) Type 1, No contact between MSF and root of extracted tooth, b) Type 2, The apex of the root was in contact with the MSF, c) Type 3, 1/3 of the root inside of the maxillary sinus, d) Type 4, More than half of the root inside of the maxillary sinus

Data Collection Method

Demographic data and the information about extracted teeth of the patients were obtained from the surgical records. The information of MSP and the relationship roots of extracted tooth to the maxillary sinus were obtained from preoperative panoramic radiographic evaluations. All data was upload excel file and the data set was created.

Statistical Analysis

Histograms, Q-Q plots, and the Shapiro-Wilk test were used to evaluate distribution of data. Descriptive statistics were calculated for each variable. The Levene's test was used homogeneity of variance. One-way ANOVA and Kruskal-Wallis tests were used for quantitative variables in more than two groups. The Pearson chi-square test was used to compare categorical data. All data analysis were done using Turcosa (Turcosa Ltd. Co., Turkiye) statistical software. Differences were considered significant at $p<0.05$.

RESULTS

The records of 469 patients treated for closure of OAC were scanned through the hospital registry software. Forty patients were excluded the study due to incomplete records. The study completed with 429 patients. Descriptive data was shown in

Table 1. 182 were female and 247 were male. The mean age of 39.90±13.90 years. Of the extracted teeth, 209 (48.72%) were first molars, 116 (27.04%) were second molars, 74(17.25%) were third molars, and 30(6.99%) were second premolars. The maxillary sinus was drooping in the entire posterior region in 252 (58.74%) patients. In 79 (18.41%) patients, the cortical margin of the maxillary sinus could not be clearly distinguished. In 58 (13.52%) patients, the sinus was drooping only in the extracted tooth area. There was no drooping of the maxillary sinus in 25(5.83) patients. In 15 (3.50%) patients, MSF line followed roots. In 167 (38.93%) patients, 1/3 of the roots of the extracted tooth were associated with the maxillary sinus. In 149 (34.73%) patients, more than half of the roots were inside the maxillary sinus. In 105(24.48%) patients, the roots of the extracted tooth were in contact with the cortical of MSF. In 8 (1.86%) patients, the roots of the extracted tooth were not related to the MSF. Descriptive data was shown in Table 1.

Table 1. Descriptive Data of demographic variables

Variable	Total (n=429)
Age (years)	39.90±13.90
Sex	
Female	182 (42.42)
Male	247 (57.58)
Extracted teeth	
2nd premolar	30 (6.99)
1st molar	209 (48.72)
2nd molar	116 (27.04)
3rd molar	74 (17.25)
Type of sinus pneumatization	
Type A	25 (5.83)
Type B	58 (13.52)
Type C	252 (58.74)
Type D	15 (3.50)
Type E	79 (18.41)
Relationship between extracted tooth and maxillary sinus	
Type 1	8 (1.86)
Type 2	105 (24.48)
Type 3	167 (38.93)
Type 4	149 (34.73)

Data are expressed as n (%), Key: Type A: Maxillary sinus without dropping, Type B: The maxillary sinus dropped only in extracted teeth area, Type C: The maxillary sinus dropped in posterior maxillary area, Type D: The line of maxillary sinus floor follows the roots, Type E: The maxillary sinus drops over the roots, but its borders are not clear, Type 1: No contact between root and maxillary sinus floor, Type 2: The apex of the root was in contact with the cortical border of the maxillary sinus, Type 3: 1/3 of the root exceeds the maxillary sinus cortical border, Type 4: More than half of the root inside of the maxillary sinus

Table 2 shows the distribution of age, sex, and extracted teeth in the sinus pneumatization groups. The mean age was 40.6±12.09 years in in the type A MSP group, 44.28±12.04 years in the type B MSP, 39.82±13.91 years in the type C MSP, 34.8±12.23 years in the type D MSP, 37.70±15.37 years in the type E MSP. There was a statistically significant difference between type B and type A in terms of age (p=0.008). Gender distribution was statistically similar between the groups (p=0.093). In all types of MSP, OAC developed mostly due to extraction of 1st molar. This was mostly followed by 2nd and 3rd molar. The highest rate of OAC due to extraction of second premolar (9.13%) was observed in type C, the highest rate of OAC due to extraction of second molar (43%) was observed in type B, and the rate of OAC due to extraction of third molar (24%) was most observed in type A. There was a statistically significant relationship between MSP groups in terms of extracted tooth (p<0.001). This difference is between type B-type C and type C-type E. This difference is due to the high 2nd molar ratio and low 2nd premolar ratio in type B and type C. In addition, the 1st molar ratio in type C is 45.24% while type E is 64.55%.

Table 3 shows the relationship between covariates and the primary outcome variable. The mean age was 49.88±19.45 years in the type 1 group, 43.17±13.99 years in the type 2 group, 40.62±13.82 years in the type 3 group, 36.26±12.79 years in the type 4 group. There was a statistically significant difference between type 4 and other groups in terms of age (p<0.001). The gender distribution was not statistically significant different between the groups(p=0.831). More than half of the roots of 41.63% of the first molars were in the maxillary sinus, and 1/3 of the roots of 39.23% were in the maxillary sinus. 17.22% were at the cortical border of the sinus, and 1.92% were not related to the sinus. While the roots of 38.79% of the second molars were in contact with the floor of the maxillary sinus, more than half of the roots of 30.17% and 1/3 of the roots of 29.31% were in the maxillary sinus. 1/3 of the roots of 51.35% of the third molars were in the maxillary sinus, more than half of the roots of 25.68% were in the maxillary sinus, and 22.97% were in contact with the floor of the maxillary sinus. There was a statistically significant relationship with extracted tooth and relationship between extracted teeth and maxillary sinus (p<0.001).

The relationship between the predictor variable (sinus pneumatization type) and primary outcome (type of relationship between extracted teeth and maxillary sinus) was given in Table 4. When the maxillary sinus was drooping in the entire posterior region (type C), 1/3 of the roots were inside the maxillary sinus (type 3) in 46.03% of the extracted teeth. In 37.70%, more than half of the roots were inside the maxillary sinus (type 4) and in 16.27% the roots were in contact with the maxillary sinus cortical (type 2). When the maxillary sinus was drooping only in the extracted tooth region (type B), 46.55% of the extracted teeth were in contact with the cortical of the maxillary sinus (type 2), 1/3 of the roots of 39.66% were within the maxillary sinus (type 3), and more than half of the roots of 12.1% were inside the maxillary sinus (type 4). If the maxillary sinus was drooping and its borders could not be clearly distinguished (type E), more than half of the roots of 56.96% of the extracted teeth were inside the maxillary sinus (type 4), 1/3 of the roots of 26.58% were inside the maxillary sinus (type 3), and 12.66% of the roots were in the cortical of the maxillary sinus (type 2). If the line of sinus followed the roots (type D), 86.67% of the extracted teeth were in contact with the cortical of the maxillary sinus (type 2), and 1/3 of the roots were inside the maxillary sinus in 13.33% (type 3). If the maxillary sinus is not prolapsed (type A), 56% of the extracted teeth are in contact with the cortical

Table 2. Comparison of demographic variable and extracted teeth between the sinus pneumatization groups

Variable	Type of maxillary sinus pneumatization					p
	Type A (n=25)	Type B (n=58)	Type C (n=252)	Type D (n=15)	Type E (n=79)	
Age (years)	40.6±12.09[ab] 40 (32-46)	44.28±12.04[a] 44 (36.75-53)	39.82±13.91[ab] 38 (29-49.75)	34.8±12.23[ab] 36 (25-41)	37.70±15.37[b] 35 (25-48)	0.008[ŋ]
Sex						
Female	16 (8.79)	29 (15.93)	103 (56.59)	6 (3.30)	28 (15.38)	0.093[†]
Male	9 (3.64)	29 (11.74)	149 (60.32)	9 (3.64)	51 (20.65)	
Extracted teeth						
2nd premolar	2 (8)[ac]	2 (3.45)[ab]	23 (9.13)[c]	2 (13.34)[abc]	1 (1.27)[ab]	<0.001[†]
1st molar	11 (44)	28 (48.28)	114 (45.24)	5 (33.33)	51 (64.55)	
2nd molar	6 (24)	25 (43.10)	61 (24.21)	5 (33.33)	19(24.05)	
3rd molar	6 (24)	3 (5.18)	54 (21.43)	3 (20)	8(10.13)	

Different superscript letters in the same row indicate significant differences between groups. Data are expressed as mean ± standard deviation, n (%), and median (first-third quartile). Key: Type A: Maxillary sinus without dropping, Type B: The maxillary sinus dropped only in extracted teeth area, Type C: The maxillary sinus dropped in posterior maxillary area, Type D: The line of maxillary sinus floor follows the roots, Type E: The maxillary sinus drops over the roots, but its borders are not clear, ŋ: Kruskal-Wallis test, †: Fisher exact test

Table 3. Relationship between covariates and primary outcome variable

Variable	Relationship between tooth and maxillary sinus				p
	Type 1 (n=8)	Type 2 (n=105)	Type 3 (n=167)	Type 4 (n=149)	
Age (years)	49.88±19.45[a] 43.5 (38.75-67.5)	43.17±13.99[a] 42 (34.5-51)	40.62±13.82[a] 39 (30-50)	36.26±12.79[b] 33 (25.5-44)	<0.001[ŋ]
Sex					
Female	4 (2.20)	46 (25.27)	73 (40.11)	59 (32.42)	0.831[†]
Male	4 (1.62)	59 (23.89)	94 (38.06)	90 (36.44)	
Extracted teeth					
1st premolar	2 (6.67)[a]	7 (23.33)[ab]	13 (43.33)[ac]	8 (26.67)[ac]	<0.001[†]
1st molar	4 (1.92)	36 (17.22)	82 (39.23)	87 (41.63)	
2nd molar	2 (1.72)	45 (38.79)	34 (29.31)	35 (30.17)	
3rd molar	0 (0)	17 (22.97)	38 (51.35)	19 (25.68)	

Different superscript letters in the same row indicate significant differences between groups. Data are expressed as mean ± standard deviation, n (%), and median (first-third quartile). Key: Type A: Maxillary sinus without dropping, Type B: The maxillary sinus dropped only in extracted teeth area, Type C: The maxillary sinus dropped in posterior maxillary area, Type D: The line of maxillary sinus floor follows the roots, Type E: The maxillary sinus drops over the roots, but its borders are not clear, ŋ, Kruskal-Wallis test; †: Fisher exact test

Table 4. Relationship between the predictor variable and primary outcome

Variable	Relationship between tooth and maxillary sinus				p
	Type 1 (n=8)	Type 3 (n=105)	Type 3 (n=167)	Type 4 (n=149)	
Type A	4 (16)[a]	14 (56)[b]	5 (20)[c]	2 (8)[a]	<0.001[†]
Type B	1 (1.72)	27 (46.55)	23 (39.66)	7 (12.1)	
Type C	0 (0)	41 (16.27)	116 (46.03)	95 (37.70)	
Type D	0 (0)	13 (86.67)	2 (13.33)	0 (0)	
Type E	3 (3.80)	10 (12.66)	21 (26.58)	45 (56.96)	

Different superscript letters in the same row indicate significant differences between groups. Data are expressed as n (%). Key: Type A: Maxillary sinus without dropping, Type B: The maxillary sinus dropped only in extracted teeth area, Type C: The maxillary sinus dropped in posterior maxillary area, Type D: The line of maxillary sinus floor follows the roots, Type E: The maxillary sinus drops over the roots, but its borders are not clear, Type 1: No contact between root and maxillary sinus floor, Type 2: The apex of the root was in contact with the cortical border of the maxillary sinus, Type 3: 1/3 of the root exceeds the maxillary sinus cortical border, Type 4: More than half of the root inside of the maxillary sinus

of the maxillary sinus (type 2), 1/3 of the roots of 20% are inside the maxillary sinus (type 3), 16% have no relation with the maxillary sinus (type 1), and 8% more than half of its roots were in the maxillary sinus (type 4). There was a statistically relationship between type of sinus pneumatization and type of relation between the extracted teeth and maxillary sinus (p<0.001).

DISCUSSION

The close relationship of the MSF and the upper molar roots can lead to OAC, odontogenic sinusitis, or displacement of the root inside of the maxillary sinus during maxillary molar extraction.[7] Therefore, diffuse MSP can cause complication such as OAC, odontogenic sinusitis or oroantral fistula that

can profoundly affect people's quality of life.[8] In this study, the relationship between the root of the extracted tooth and different type of MSP in patients who developed OAC during the extraction of maxillary posterior teeth was evaluated. There was a statistically relationship between type of MSP and type of relation between the extracted teeth and maxillary sinus.

Wu et al.[8] reported that the MSP was significantly associated with age. Especially, it increases in 18-34 years old group. In addition, they suggested that the determinig degree of MSP could be important before treatment of the upper molar, especially young patients. In this study there was a statistically significant difference between type of MSP in terms of age (p=0.008). In consistent with the literature, the highest mean age was in the type B (dropped only in extracted teeth area) pneumatization, while the lowest mean age was in the Type E (drops over the roots, but its borders are not clear). Diffuse MSP in young patients can increases the risk of teeth protrusion into the sinus by decreasing the distance between apex of the root and maxillary sinus[8] and, additionally, Pei et al.[6] reported that the distance between molars and MSF increases with age. This confirms that the risk of complications during molar tooth extraction, endodontic treatment or implantation is relatively higher in young patients.[6] In consistent with the literature, there was a statistically significant difference in the mean age between different type of the relation between extracted teeth and the MSF groups in this study. (p<0.001). The highest mean age was found in type 2 (contact maxillary sinus), and the lowest was found in type 4 (more than half of the roots are in the maxillary sinus). These results show that there is a close relationship between the maxillary sinus and molar teeth in young patients and may increase the risk of OAC after extraction.

Bornstein et al.,[9] Luz et al.[10] and Cavalcanti et al.[11] reported that there was a statistically difference between male and female in terms of MSP. Further analysis showed that the difference may be due to larger skulls and body proportions in males and a higher MSP rating. However, Pei et al.[6] showed that female molars were closer to the maxillary sinus than males, but these differences were not statistically significant. In this study, the proportion of men (57.58%) was higher than women (42.42%). MSP was extensive in men than in women, but the relationship was not statistically significant (p<0.005). Takahashi et al.[12] stated that although maxillary sinus volume decreases with age, there is no significant difference between male and female, which can be explained by the decrease in female gender in the study group. The sex distribution was similar in the types of relationship between the extracted tooth and the maxillary sinus groups in this study (p>0.005).

The maxillary molar roots are very close to MSF. Previous studies have reported that in approximately 50% of patients, the maxillary sinus prolapses towards the alveolar bone, which may extend between roots of the teeth.[13] In addition, Sharan and Madjar[14] suggested that maxillary molar extraction could lead to MSP. It can cause if the apex of the root close to the maxillary sinus. In this study, 96.5% of the extracted teeth were in contact or inside to the maxillary sinus. Only 3.5% were distant from the MSF. OAC was most often seen after the extraction of the first molar, followed by the second molar. Purmal et al.[15] found that the MSF was most inferior location between the right molars. In addition, the highest location was between the left premolars. The buccal roots of the upper second molar were nearest to the MSF.[14,16,17] However, Themkumkwun et al.[18] analyzed 354 upper molar roots on CBCT. They found that extending of the molar roots into the maxillary sinus were common. Zhang et al.[19] reported that that half of the molar roots were inside of the maxillary sinus or in contact with MSF. Jung et al.[20] also found that the most common type of molar buccal root is entering the maxillary sinus. In contrast to literature, more than half of the roots of 41.63% of the first molars were in the maxillary sinus, and 1/3 of the roots of 39.23% were in the maxillary sinus. 17.22% were at the cortical border of the sinus, and 1.92% were not related to the sinus. While the roots of 38.79% of the second molars were in contact with the MSF, more than half of the roots of 30.17% and 1/3 of the roots of 29.31% were in the maxillary sinus. There was a statistically significant relationship with extracted tooth and relationship between extracted teeth and maxillary sinus in this study (p<0.001).

The previous studies evaluated the relationship of molar teeth to the maxillary sinus on CBCT. However, this study was the first to evaluate both the types of MSP and the relationship between the extracted tooth and the maxillary sinus in patients who developed OAC after extraction of maxillary molars. In this study, type C MSP (pneumatization in the entire posterior region of the maxillary sinus) had the highest rate. In 46.03% of them, 1/3 of the roots of the extracted tooth were in the maxillary sinus, and in 37.70%, more than half of the roots of the extracted tooth were in the maxillary sinus. After type C, the highest rate was type E. More than half of the roots of 56.96% of them, and 1/3 of the roots of 26.58% were in the maxillary sinus. These results indicate that the risk of developing OAC during the extraction of maxillary molar teeth increases in patients where the maxillary sinus sags in the entire posterior or its borders cannot be distinguished. The periapical or panoramic x-ray don't allow 3D evaluation of the relationship when molar roots superposed to the MSF.[21] A CBCT images provides 3D evaluation of the relationship between MSF and molar roots. The 3D evaluation provided on CBCT allow for rationalization of surgical plans to avoid risk for oroantral perforation.[22] However, in this study, evaluation was made on preoperative panoramic radiographs due to its retrospective natures. In addition, taking a CBCT image before the tooth extraction is not a routine procedure. But it may have caused limitations in determining the relationship between the maxillary sinus and the teeth. The difference mentioned above may have arisen for this reason or due to different racial and genetic origins.

CONCLUSION

The risk of developing OAC during the extraction of maxillary molar teeth increases in young patients where the maxillary sinus dropped in the entire posterior region or its borders cannot be distinguished. A compherensive analysis should be performed on CBCT in patients with high risk of OAC development during the interventions to the maxillary posterior region.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of the Clinical Researches Ethics Committee of Erciyes University Faculty of Medicine (Date: 29.03.2023, Decision No: 2023-204)

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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