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Can CT predict the development of oroantral fistula in patients undergoing maxillary third molar removal?

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Short title: **Can CT predict the development of oroantral fistula?**

ABSTRACT

Purpose

In maxillary wisdom tooth extraction, the necessity of CT is unknown. The purpose of this study was to investigate whether CT adding to orthopantomography is useful for predicting oroantral perforation during maxillary third molar extraction.

Methods

Various risk factors for oroantral perforation during maxillary third molar extraction were investigated by univariate and multivariate analyses. We analyzed those of all patients and the patients who underwent CT, respectively. The proximity of the roots to the maxillary sinus floor (root-sinus [RS] classification) and Archer classification were assessed using panoramic radiography. The number of roots and Vertical relationship were assessed using CT.

Results

604 out of 3299 patients underwent CT adding to orthopantomography. In all cases, multivariate analyses except for CT findings showed that the RS classification Type III/IV and the Archer classification Type B/C/D in panoramic findings were significantly correlated with oroantral perforation as radiological findings. In cases for which CT was performed, multivariate analyses showed that one root (OR 12.87) and the Vertical

relationship Type D (OR 5.63) in CT findings, besides the RS classification Type III/IV (OR 4.47) in panoramic findings, were significantly related to oroantral perforation.

Conclusion

The RS classification and the Archer classification in panoramic findings can predict the risk of oroantral perforation. The usefulness of CT adding to orthopantomography is limited. However, when the relationship between the upper wisdom tooth and maxillary sinus floor (RS classification) is unclear, to check whether the number of roots is one and the apex of one root is projecting into the maxillary sinus in CT findings, is useful for the prediction.

1. INTRODUCTION

Maxillary third molar extraction is one of the most common surgical interventions in oral and maxillofacial surgery. This operation involves the risk of complications, including oroantral perforation [1-3]. An oroantral perforation may cause maxillary sinusitis or formation of an oronasal fistula, causing concern to the patient [4-6]. Therefore, predicting risk factors is important in preventing the incidence of oroantral perforation. However, few studies have analyzed the risk factors associated with oroantral perforation during the maxillary third molar extraction [7-9].

In addition, CT is currently used worldwide, as a preoperative diagnostic tool to be able to extract exact information regarding the position of disease. In fact, CT is sometimes performed adding to orthopantomography before maxillary wisdom tooth extraction. However, there are no reports that analyzed the usefulness of CT for predicting oroantral perforation during the maxillary third molar extraction.

In the present study, we conducted a multicentric retrospective study to analyze whether CT adding to orthopantomography is useful for predicting oroantral perforation.

2. PATIENTS & METHODS

2.1.Patients

In this study, inclusion criteria was set for patients above fifteen years old, and exclusion criteria was set for patients who hoped non-participate after the publication of this study. Altogether, a total of 3299 patients underwent maxillary third molar extraction from January 2014 to December 2016 at nine hospitals included in this study; these include Kakogawa Central City Hospital, Kobe University Hospital, Shin-suma General Hospital, Saiseikai Hyogo-ken Hospital, Kobe Central Hospital, Hyogo Prefectural Awaji Medical Center, Mitsubishi Kobe Hospital, Kawasaki Hospital, and Kita-Harima Medical Center. Of all patients, at the surgeon's discretion, a total of 604 patients underwent preoperative CT. The most cases for which CT was performed were when the lower wisdom tooth close to the inferior alveolar nerve was also planned to extract at the same time. The institutional review board of Kobe University Hospital approved the study design (authorization number: 170020).

2.2.Surgical procedure

Tooth extraction was performed under local anesthesia, and local anesthesia was administered using 1.8-3.6 mL of 2% lidocaine containing 1/80000 units of epinephrine.

The teeth were extracted by a rotation and traction movement with elevators. In addition, by the surgeon's judgement, incision or bone removal were added. Mucoperiosteal flaps were raised to expose impacted teeth, followed by bone removal as necessary. Incisions were closed using 3–0 silk sutures and removed after 7 days. An oroantral perforation was identified by nose blowing and careful probing of the extraction socket, using a blunt sinus probe. Antibiotics and anti-inflammatory drugs were prescribed as necessary.

2.3.Variables

The objective was to identify the occurrence of oroantral perforation during maxillary third molar extraction. The following variables from medical records were retrospectively reviewed and investigated: (1) Patient factors—sex and age (2) Surgery factors—anesthesia and surgeon's experience (3) Clinical findings—preoperative complaint, eruption, and position (4) The factors of panoramic findings—Archer classification, inclination, root apex completeness, and the roots of the maxillary sinus floor classification (RS classification). (5) Treatment factors—incision, bone removal, fracture of the maxillary tuberosity, and remarkable hemorrhage.

Moreover, in the cases of patients who underwent CT before maxillary third molar extraction, some CT findings were additionally investigated; the Vertical relationship between the root of the teeth and the sinus floor, the Horizontal relationship, and the number of roots.

In panoramic findings, we used two classifications— the Archer classification and the RS classification, which were used by some papers [9, 10]. First, the Archer classification is based on the position of the long axis of the maxillary third molar relative to the long axis of the maxillary second molar. By modifying this classification, the relation between the maxillary third molar and the maxillary second molar was classified into four types: (1) Type A: the maxillary third molar was at or below the occlusal plane. (2) Type B: the maxillary third molar was between the occlusal plane and the cervical line. (3) Type C: the maxillary third molar was between the cervical line of the second molar and the middle third of its root. (4) Type D: the maxillary third molar was at or above the apical third of the root of the second molar (Fig. 1).

Next, the RS classification is based on the relation between the line of the maxillary sinus floor and the root apex of the maxillary molar [9]. In type I, the line of the maxillary sinus floor curved gently and was distinct from the root apex (Fig. 2). In type II, the line of the maxillary sinus floor was curved sharply and was partially superimposed across the root apex. In type III, the line of the maxillary sinus floor dropped extensively between the premolar and the maxillary third molar and was superimposed across most or all of the roots. In type IV, the line of maxillary sinus floor impinged on the root apex; however, it dropped only between the roots. In type V, the relationship between the line of the maxillary sinus floor and the root apex was indistinct.

In CT findings, this study used two classifications, which were used by the report of Jung et al [11]. First, in DentaScan of CT imaging, the Vertical relationship between the longest root of the tooth and the sinus floor was categorized into four types: Type A, the root was not in contact with the cortical borders of the sinus; Type B, the root was in contact with the cortical borders of the sinus; Type C, the root was projecting laterally on the sinus cavity, but its apex was outside the sinus borders; and Type D, the root apex was projecting into the sinus cavity (Fig. 3). Next, in DentaScan of CT imaging, the Horizontal relationship was categorized into three types: Type 1, the lowest point of the sinus floor was located on the buccal side; Type 2, the lowest point of the sinus floor was located between the buccal and palatal roots; Type 3, the lowest point of the sinus floor was located on the palatal side of the palatal root (Fig. 4).

2.4.Statistical analyses

Statistical analyses were performed using SPSS 15.0 (SPSS, Chicago, IL). The association of each variable with the oroantral perforation was analyzed by the non-parametric Mann-Whitney U test for ordinal variables, and either Fisher's exact test or chi-squared test was used for the categorical variables. Probabilities of less than 0.05 were accepted as significant.

3. RESULTS

3.1 Patient factors in all cases

Oroantral perforation occurred in 46 out of 3299 extractions (1.4%) (Table 1). According to univariate analysis, there was a significant difference between the occurrence of oroantral perforation and the mean age of patients.

3.2 Surgery factors in all cases

According to univariate analysis, the third molars extracted under general anesthesia caused a higher probability of oroantral perforations than those under local anesthesia (Table 1). In contrast, the surgeon's experience did not influence the occurrence of oroantral perforation.

3.3 Clinical findings in all cases

Univariate analysis showed that significant differences in the occurrence of oroantral perforation were observed in relation to the preoperative complaint and eruption (Table 1). In particular, pericoronitis was significantly associated with oroantral perforation in multivariate analysis (odds ratio [OR]: 4.23, 95% confidence interval [CI]: 1.80–24.10) (Table 2). However, there was no significant difference in the rate of complications between the left and right maxillary third molar extractions.

3.4 Panoramic findings in all cases

Univariate analysis revealed that Archer classification, inclination, and RS classification significantly correlated with the rate of oroantral perforation (Table 1). Multivariate analysis showed that Archer classification Type B/C/D (OR: 4.39, 95% CI: 1.27–15.17) and RS classification Type III/IV (OR: 2.53, 95% CI: 1.28–4.97) were significant risk factors in the occurrence of oroantral perforation (Table 2). Conversely, the oroantral perforation and the root apex completeness did not have a statistically significant correlation according to the univariate analysis outcomes.

3.5 Treatment factors in all cases

Significant differences in the occurrence of oroantral perforation were observed with the presence or absence of incision, bone removal, and fracture of the maxillary tuberosity (Table 1). Multivariate analysis showed that the presence of incision (OR: 3.87, 95% CI: 1.49–7.10) and fracture of the maxillary tuberosity (OR: 7.28. 95% CI: 1.45–36.44) were significant risk factors in the occurrence of oroantral perforation (Table 2).

3.6 Patient factors in the cases of patients who underwent CT

The oroantral perforation occurred in 19 out of 604 extractions in patients who underwent preoperative CT (3.1%) (Table 3). This probability was more than twice that of all cases. According to univariate analysis, there were no significant differences between the occurrence of oroantral perforation and sex or the mean ages.

3.7 Surgery factors in the cases of patients who underwent CT

The third molars extracted under general anesthesia caused more oroantral perforations than those under local anesthesia, according to univariate analysis (Table 3). In contrast, the surgeon's experience did not influence the occurrence of oroantral perforation, as in all cases.

3.8 Clinical findings in the cases of patients who underwent CT

Univariate analysis showed that significant differences in the occurrence of oroantral perforation were observed in relation to the preoperative complaint and eruption (Table 3). As in all cases, pericoronitis was significantly associated with oroantral perforation in multivariate analysis (OR: 3.97, 95% CI: 1.09–14.37) (Table 4).

3.9 Panoramic findings in the cases of patients who underwent CT

As in all cases, univariate analysis revealed that Archer classification, inclination, and RS classification significantly correlated with the rate of oroantral perforation (Table 3). Multivariate analysis showed that RS classification Type III/IV (OR: 4.47, 95% CI: 1.33–15.04) was a significant risk factor in the occurrence of oroantral perforation (Table 4).

The most cases of oroantral perforation was RS classification Type III/IV and Archer classification Type B/C/D (Table 3). Here is a case which occurred oroantral perforation (Fig. 5). The position of upper wisdom tooth was Archer classification Type B and the line of maxillary sinus floor was RS classification Type III. However, the relationship between the upper wisdom tooth and maxillary sinus floor was unclear (Fig. 5A).

3.10 CT findings in the cases of patients who underwent CT

Univariate analysis revealed that Vertical relationship was significantly correlated with the rate of oroantral perforation (Table 3). Moreover, multivariate analysis showed that Vertical relationship (Type D) (OR: 5.63, 95% CI: 1.89–16.71) and one root (OR: 12.87, 95% CI: 1.23–135.00) were significant risk factors in the occurrence of oroantral perforation (Table 4). Conversely, the Horizontal relationship did not have a statistically significant correlation according to the univariate analysis outcomes.

The most cases of oroantral perforation was one root and the Vertical relationship Type D (Table 3). Here is a case which occurred oroantral perforation (Fig. 5). The relationship between upper wisdom tooth and the maxillary sinus floor was Vertical relationship Type D and Horizontal relationship Type 2, and the apex of one root was projecting into the maxillary sinus in CT findings (Fig. 5B).

3.11 Treatment factors in the cases of patients who underwent CT

Significant differences in the occurrence of oroantral perforation were observed with the presence or absence of incision and bone removal (Table 3). Multivariate analysis showed that the presence of bone removal (OR: 8.68, 95% CI: 2.23–33.77) and remarkable hemorrhage (OR: 18.01, 95% CI: 1.75–185.30) were significant risk factors in the occurrence of oroantral perforation (Table 4).

4. DISCUSSION

In the present study, we investigated whether CT adding to orthopantomography is useful for predicting oroantral perforation. In all cases, multivariate analyses except for CT findings showed that RS classification Type III/IV and Archer classification Type B/C/D in panoramic findings were significantly correlated with oroantral perforation as radiological findings. In the other hand, in the case for which CT was performed, multivariate analyses showed that RS classification Type III/IV in panoramic finding and Vertical relationship Type D in CT finding was significantly related to oroantral perforation. In addition, we found that one root was also significant factor by multivariate analyses.

In the present study, the rate of oroantral perforation was 1.4% (46 among 3299 teeth) in the analysis of all cases. Univariate analysis showed that patient factor (age), clinical findings (preoperative complaint and eruption), some panoramic findings (Archer classification, Inclination, and RS classification), and some treatment factors (incision, bone removal, fracture of the maxillary tuberosity, and remarkable-hemorrhage) were significantly correlated with oroantral perforation. In the other hand, the rate of oroantral perforation in the cases of patients who underwent CT was 19 out of 604 teeth (3.1%). Univariate analysis showed that clinical findings (preoperative complaint and eruption), some panoramic findings (Archer classification, Inclination, and RS classification), CT finding (Vertical relationship), and some treatment factors (incision, bone removal, and remarkable-hemorrhage) were significantly associated with oroantral perforation.

Some studies have reported the incidence of oroantral perforation to be ranging from 2.5–13.0% [7, 8]. The rate of oroantral perforation in this study was similar to other reports [7, 8, 12-14]. Both in all cases and in the cases of patients who underwent CT, multivariate analysis showed that pericoronitis and remarkable-hemorrhage were significantly correlated with oroantral perforation. Some reports showed that chronic apical infection of the tooth might cause bone resorption and reduce the distance between the maxillary sinus and the teeth. It may also cause bone sclerosis and render the bone of the tuberosity more liable to fracture [15, 16]. Therefore, pericoronitis can increase the risk of oroantral perforation during the extraction of maxillary wisdom tooth. The maxillary tuberosity fracture, which was significant risk factor in the analyses of all cases, some studies reported that chronic apical infection of the tooth might result in bone sclerosis and render the bone of the tuberosity more liable to fracture [15, 16]. Remarkable hemorrhage is also associated with fracture of the maxillary. When the range of maxillary tuberosity fracture is extensive, it is a situation of special concern, which can result in remarkable hemorrhage due to the proximity of significant vessels to the area

[16, 17].

In the analysis of all cases, there was a significant difference between the occurrence of oroantral perforation and the mean age of patients in univariate analysis (Table 1). This is probably due to the eruption because the eruption depth of tooth is deeper in younger people. In fact, the eruption was also significantly associated with the occurrence of oroantral perforation (Table 1). Some reports also showed this relationship [11, 18]. In addition, RS classification and Archer classification in panoramic findings were significantly correlated with oroantral perforation. A few reports also showed that the RS classification was significantly associated with the occurrence of oral perforation [9, 19]. In the cases for which CT was performed, one root and the Vertical relationship Type D in CT findings were significant risk factor, instead of Archer classification Type B/C/D in panoramic findings. These results showed that in vertical position of the tooth, the Vertical relationship Type D may be more significant risk factor of oroantral perforation than Archer classification Type B/C/D. Interestingly, in this study, 18 out of 19 oroantral perforation cases in the cases of patients who underwent CT were one root (Table 3). To our knowledge, no reports have analyzed the relationship between the number of roots and oroantral perforation. The exact number of roots and the exact position can be checked by DentaScan of CT imaging, but difficult by orthopantomography. Lewusz-Butkiewicz et al. also reported that orthopantomogram assessment is not a reliable method for assessing the risk of oroantral perforation and that CT or cone-beam computed tomography (CBCT) should be performed to verify the condition [18, 20, 21]. Our results indicated that when the relationship between the upper wisdom tooth and maxillary sinus floor (RS classification) is unclear, to check whether the number of roots is one and the apex of one root is projecting into the maxillary sinus in CT findings, is useful for the prediction.

However, this study has some weaknesses. First, there is a possibility of unknown confounding factors because this is a retrospective study. Second, the nine hospitals do not have the criteria in which cases taking CT before maxillary third molar extraction. Third, it is not clear whether CT adding actually affected the postoperative outcome (i.e., prevention of oroantral perforation), because of retrospective nature. Fourth, there may be race differences. Masaki et al reported that 75.4% of 601 maxillary wisdom teeth in Japanese people was one root [22]. To our knowledge, there are no reports which investigated the number of upper wisdom tooth in each race. Therefore, it is not clear whether one root is high risk of oroantral perforation in other races than Japanese. Finally, Japanese patients can undergo CT at low cost because Japan has system of the public health insurance for the whole nation, dislike other countries.

In conclusion, this is the first report analyzed the risk factor of oroantral perforation during maxillary third molar extraction with CT findings. The Archer classification and RS classification in panoramic findings are significant risk factors of oroantral perforation. However, when the relationship between the upper wisdom tooth and maxillary sinus floor (RS classification) is unclear, to check whether the number of roots is one and the apex of one root is projecting into the maxillary sinus in CT findings, is useful for the prediction. When the number of roots is one and the apex of one root is projecting into the maxillary sinus in CT findings, surgeons should inform patients the high risk of oroantral perforation before tooth extraction and take precautionary measures, for example preparing the splint to cover the perforation part. We hope that the results of this study will be useful in future for predicting the possibility of oroantral perforation, informing patients, and obtaining consent.

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TABLE AND FIGURE CAPTIONS

Figure 1: Archer classification in panoramic finding

Type A: the maxillary third molar is at or below the occlusal plane. Type B: the maxillary third molar is between the occlusal plane and the cervical line. Type C: the maxillary third molar is between the cervical line of the second molar and the middle third of its root. Type D: the maxillary third molar is at or above the apical third of the root of the second molar tooth.

Figure 2: RS classification in panoramic finding

Type I: the line of maxillary sinus floor curved gently and is clearly distinct from the root apex. Type II: the line of maxillary sinus floor curved sharply and is partially superimposed across the root apex. Type III: the line of maxillary sinus floor dropped extensively between the premolar and the maxillary third molar and is superimposed across most or all roots. Type IV: the line of maxillary sinus floor impinged on the root apex, however, dropped only between the roots. Type V: the relationship between the line of the maxillary sinus floor and the root apex is indistinct.

Figure 3: Vertical relationship in CT finding

Type A: the root is not in contact with the cortical borders of the sinus. Type B: the root is in contact with the cortical borders of the sinus. Type C: the root is projecting laterally on the sinus cavity, but its apex is outside the sinus borders. Type D: the root apex is projecting into the sinus cavity.

Figure 4: Horizontal relationship in CT finding

Type 1: the lowest point of the sinus floor is located on the buccal side. Type 2: the lowest point of the sinus floor is located between the buccal and palatal roots. Type 3: the lowest point of the sinus floor is located on the palatal side of the palatal root.

Figure 5: The radiological imaging of a case which occurred oroantral perforation

A: In panoramic findings, the position of upper wisdom tooth was Archer classification Type B and the line of maxillary sinus floor was RS classification Type III. However, the relationship between the upper wisdom tooth and maxillary sinus floor was unclear.

B: In CT findings, the relationship between upper wisdom tooth and the maxillary sinus floor was Vertical relationship Type D and Horizontal relationship Type 2, and the apex of one root was projecting into the maxillary sinus.

Table 1: Results of univariate analysis of the risk factors for oroantral perforation during surgical extraction of maxillary third molars

Values are expressed as absolute numbers, with the corresponding percentage of the total in parentheses. Values in the right-hand column indicate the statistical significance of the difference between subgroups. Age is expressed as the mean ± standard deviation in a parametric ratio scale.

*significant

Table 2: The results of the multivariate logistic regression analysis of the risk factors of oroantral perforation during surgical extraction of maxillary third molars

Data are the p-value, odds ratio and 95% confidence interval (CI) for those factors found to be significantly associated with an increased risk of oroantral perforation.

Table 3: Results of univariate analysis of the risk factors for oroantral perforation during surgical extraction of maxillary third molars in the cases of patients who underwent CT

Values are expressed as absolute numbers, with the corresponding percentage of the total in parentheses. Values in the right-hand column indicate the statistical significance of the difference between subgroups. Age is expressed as the mean ± standard deviation in a parametric ratio scale.

*significant

Table 4: The results of the multivariate logistic regression analysis of the risk factors of oroantral perforation during surgical extraction of maxillary third molars in the cases of patients who underwent CT

Data are the p-value, odds ratio and 95% confidence interval (CI) for those factors found to be significantly associated with an increased risk of oroantral perforation.

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Compliance with Ethical Standards

Informed consent was obtained from all individual participants included in the study. For patients aged <18 years, informed consent was sought from their parent/guardian. This retrospective study has been conducted in full accordance with the World Medical Association Declaration of Helsinki and was approved by the institutional review board of Kobe University Hospital (authorization number: 170020).

AUTHOR CONTRIBUTIONS

Study design: E Iwata, T Hasegawa

Acquisition of data: E Iwata E, M Kobayashi, N Takata, T Oko, D Takeda, Y Ishida, T Fujita, I Goto, J Takeuchi

Analysis and interpretation of data: E Iwata, T Hasegawa, A Tachibana, M Akashi

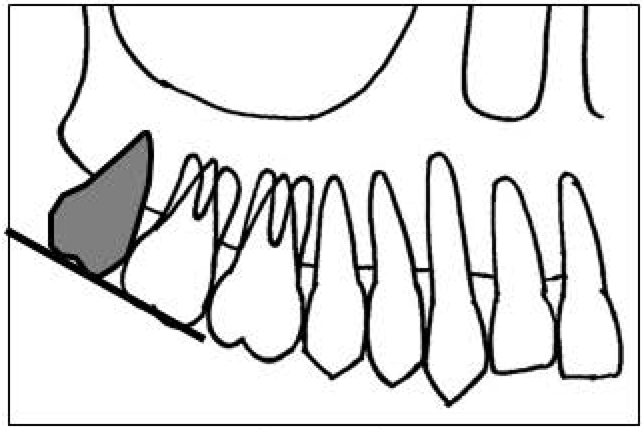
Manuscript preparation: E Iwata, T Hasegawa, M Kobayashi, A Tachibana, N Takata, T

Oko, D Takeda, Y Ishida, T Fujita, I Goto, J Takeuchi, M Akashi

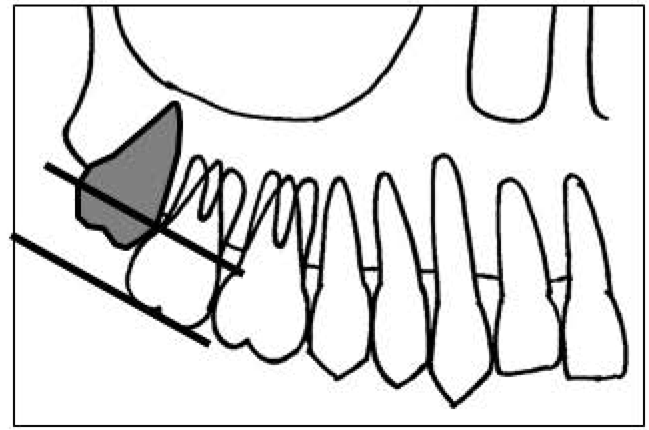
Manuscript editing: E Iwata, T Hasegawa, M Akashi

Manuscript review: E Iwata, T Hasegawa, M Kobayashi, A Tachibana, N Takata, T Oko, D Takeda, Y Ishida, T Fujita, I Goto, J Takeuchi, M Akashi

Statistical analysis: E Iwata, T Hasegawa, A Tachibana, M Akashi



Type A



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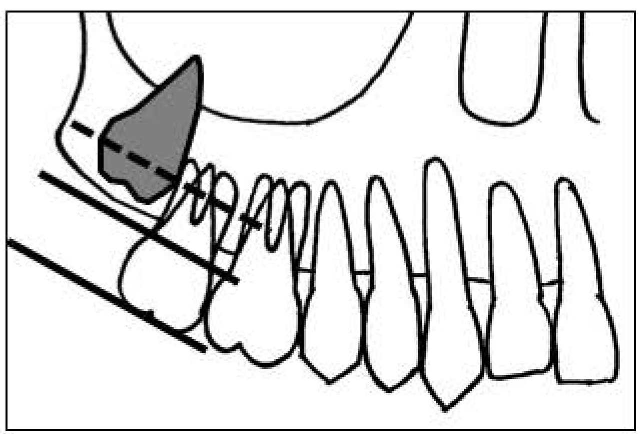

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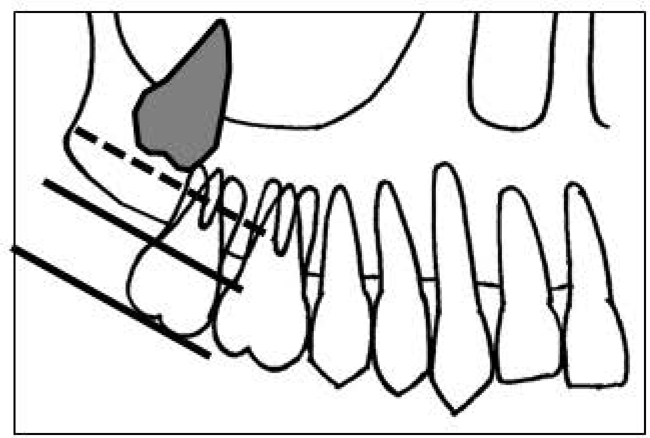

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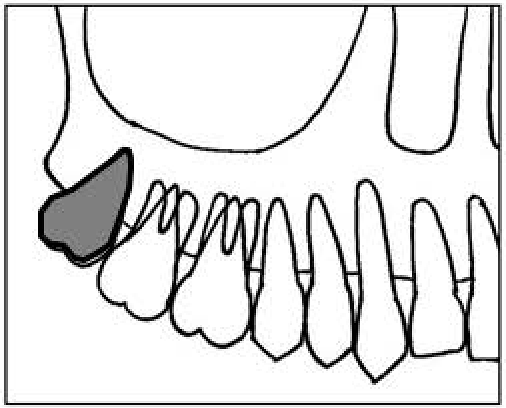

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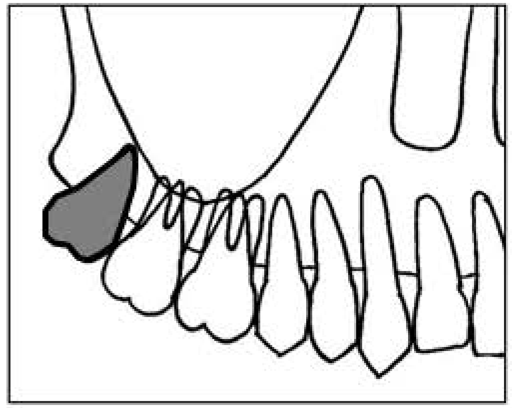

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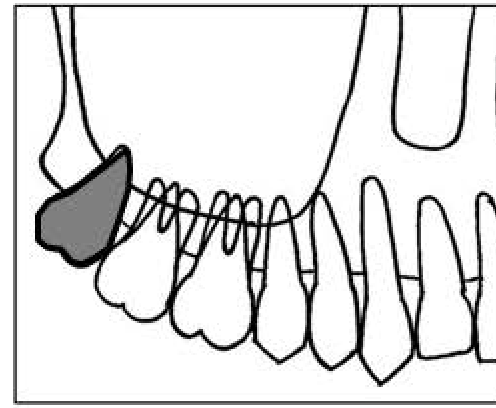

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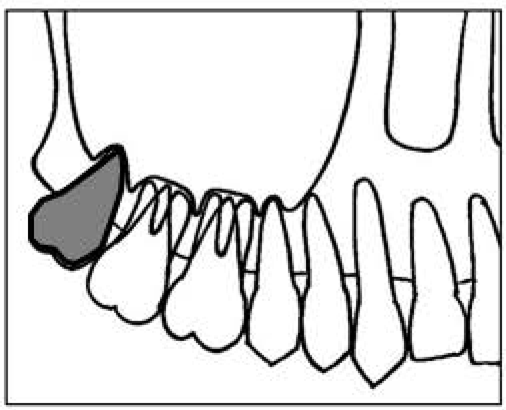

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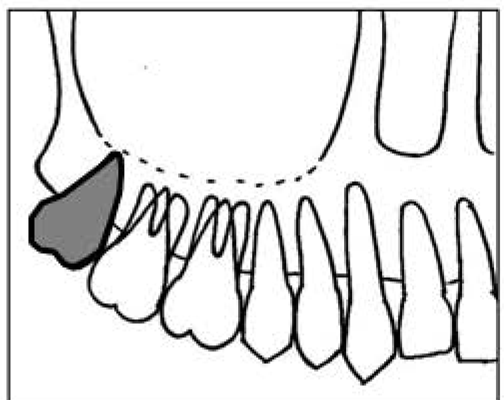


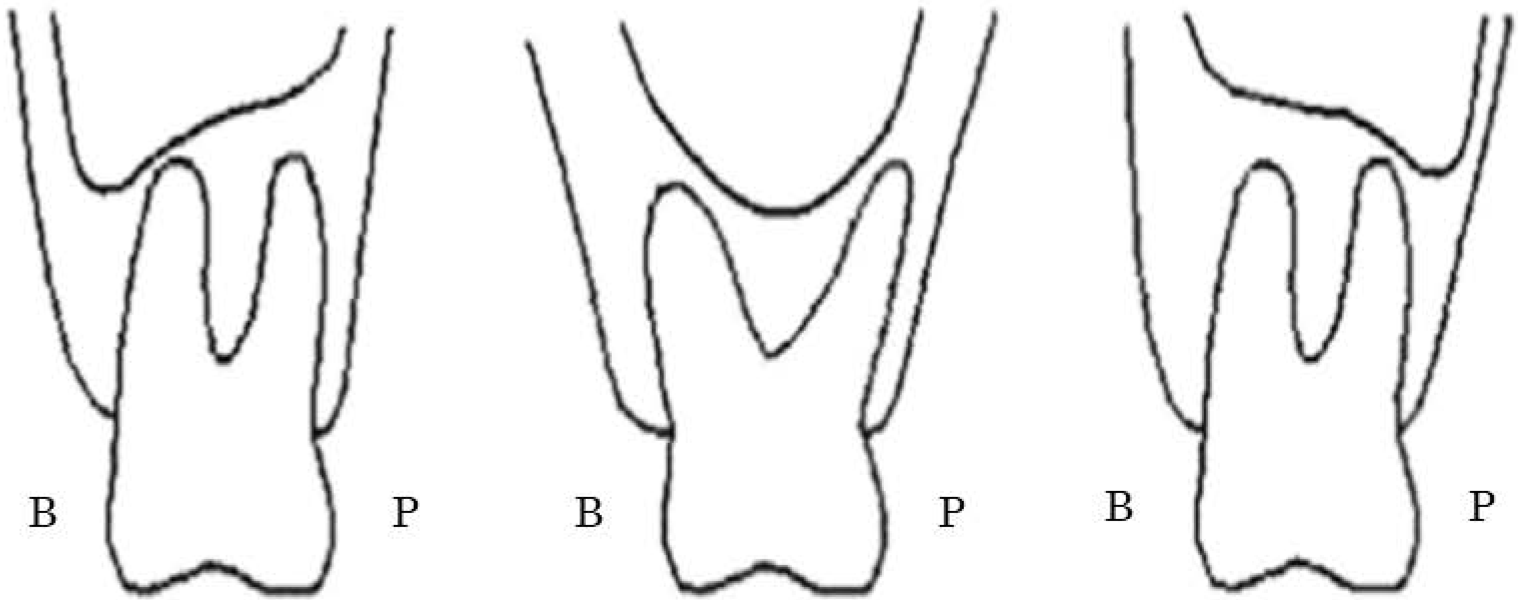
Type V

Type A

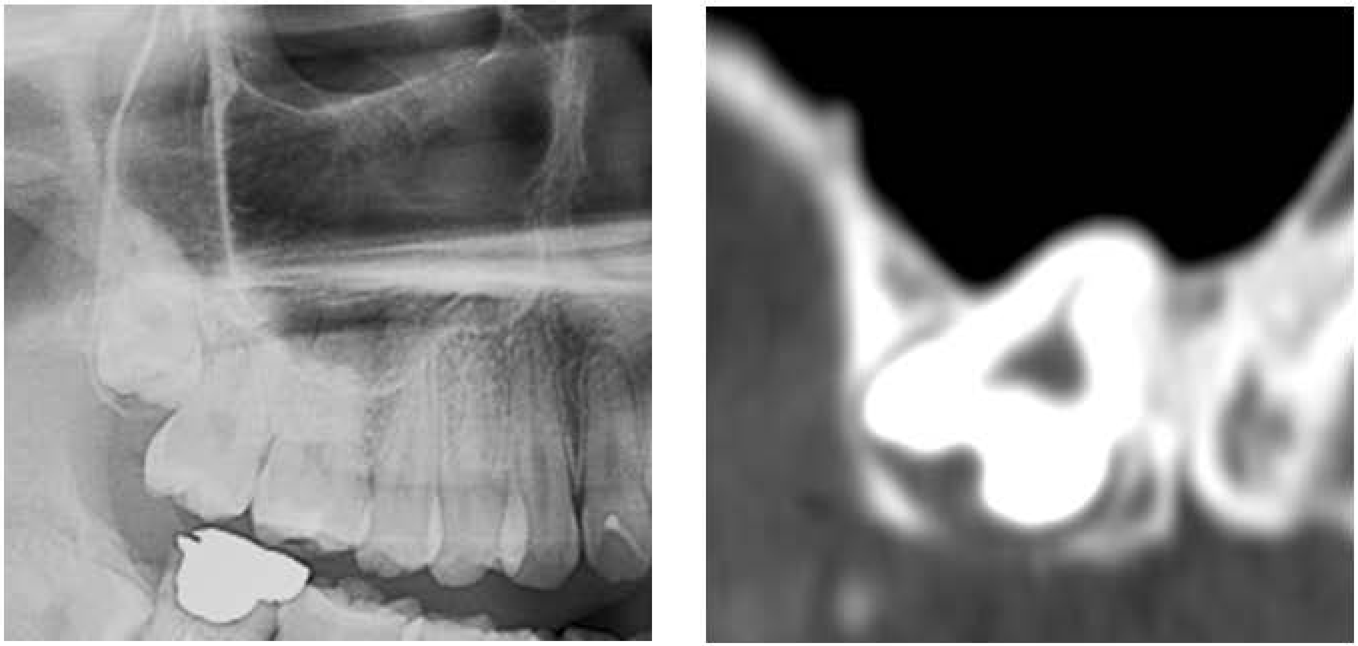
Type B

Type C

Type D



Type 1 Type 2 Type 3



A B

Table 1.

Variables	Category	Oroantral perforation		P value
		Present (n; %)	Absent (n; %)	
Sample size		46 (1.4)	3253 (98.6)	
Gender	Male	21 (45.7)	1330 (40.9)	0.548
	Female	25 (54.3)	1923 (59.1)	
Age	Range	15-85	13-94	0.005*
	Mean ± SD	37.5 ± 15.2	31.9 ± 13.2	
Anesthesia	General	19 (41.3)	972 (30.0)	0.105
	Local	27 (58.7)	2281 (70.0)	
Surgeon's experience	1-4 years	22 (47.8)	1328 (40.8)	0.183
	5-9 years	14 (30.4)	797 (24.5)	
	>10 years	10 (21.8)	1128 (34.7)	
Preoperative complaint	None	26 (56.6)	2279 (70.0)	<0.001*
	Caries	6 (13.0)	673 (20.7)	
	Pericoronitis	11 (24.0)	270 (8.3)	
	Sinusitis	0 (0.0)	5 (0.2)	
	Others	3 (6.4)	26 (0.8)	
Eruption	Fully impacted	29 (63.0)	877 (27.0)	<0.001*
	Partially impacted	12 (26.1)	570 (17.5)	
	Erupted	5 (10.9)	1806 (55.5)	
Position	Left	22 (47.8)	1630 (50.1)	0.769
	Right	24 (52.2)	1623 (49.9)	
Archer classification	Type A	4 (8.7)	1677 (51.6)	<0.001*
	Type B	16 (34.8)	947 (29.1)	
	Type C	17 (37.0)	518 (15.9)	
	Type D	9 (19.5)	111 (3.4)	
Inclination	Vertical	16 (34.8)	2272 (69.8)	<0.001*
	Forward Inclination	23 (50.0)	571 (17.6)	
	Aft Inclination	4 (8.7)	289 (8.6)	
	Others	3 (6.5)	131 (4.0)	
Root apex completeness	Apical closure	42 (91.4)	2868 (88.2)	0.718
	Apical patency	2 (4.3)	197 (6.1)	
	Unexploited apical (≧2/3)	0 (0.0)	71 (2.2)	
	Unexploited apical (<2/3)	2 (4.3)	117 (3.5)	
RS classification	Type I	6 (13.0)	1044 (32.2)	0.003*
	Type II	9 (19.6)	914 (28.1)	
	Type III	21 (45.7)	947 (30.0)	
	Type IV	8 (17.4)	284 (8.7)	

	Type V	2 (4.3)	64 (20.0)	
Incision	No	12 (26.1)	2081 (64.0)	<0.001*
	Yes	34 (73.9)	1172 (36.0)	
Bone removal	No	18 (40.9)	2450 (75.4)	<0.001*
	Yes	26 (59.1)	800 (24.6)	
Fracture of the maxillary tuberosity	No	40 (87.0)	3299 (99.3)	0.046*
	Yes	6 (13.0)	24 (0.7)	
Remarkable-hemorrhage	No	40 (87.0)	3229 (99.3)	0.043*
	Yes	6 (13.0)	24 (0.7)	

Table 2.

Variable	P value	Odds ratio	95% CI	
			Lower	Upper
Archer classification Type B/C/D	0.022	4.13	1.22	13.9
RS classification Type III/IV	0.018	2.16	1.14	4.08
Pericoronitis	0.003	3.12	1.49	6.57
Incision	0.016	2.94	1.22	7.06
Fracture of the maxillary tuberosity	0.003	11.10	2.29	53.9
Remarkable hemorrhage	0.026	5.82	1.24	27.4

CI. Confidence interval

Table 3.

Variables	Category	Oroantral perforation		P value
		Present (n; %)	Absent (n; %)	
Sample size		19 (3.1)	585 (96.9)	
Gender	Male	9 (47.4)	257 (43.9)	0.817
	Female	10 (52.6)	328 (56.1)	
Age	Range	20-64	15-80	0.266
	Mean ± SD	34.4 ± 10.8	31.5 ± 11.1	
Anesthesia	General	13 (68.4)	364 (62.2)	0.640
	Local	6 (31.6)	221 (37.8)	
Surgeon's experience	1-4 years	11 (57.9)	226 (38.6)	0.234
	5-9 years	5 (26.3)	209 (35.7)	
	>10 years	3 (15.8)	150 (25.7)	
Preoperative complaint	None	11 (57.9)	455 (77.8)	0.028*
	Caries	2 (10.5)	73 (12.5)	
	Pericoronitis	5 (26.3)	46 (7.9)	
	Sinusitis	0 (0.0)	4 (6.8)	
	Others	1 (5.3)	7 (12.0)	
Eruption	Fully impacted	15 (79.0)	244 (41.7)	0.005*
	Partially impacted	2 (10.5)	119 (20.3)	
	Erupted	2 (10.5)	222 (38.0)	
Position	Left	9 (47.3)	290 (49,6)	1.000
	Right	10 (52.7)	295 (50.4)	
Archer classification	Type A	1 (5.3)	204 (34.2)	0.003*
	Type B	5 (26.3)	189 (32.3)	
	Type C	9 (47.4)	155 (26.5)	
	Type D	4 (21.0)	37 (6.2)	
Inclination	Vertical	3 (15.8)	341 (58.4)	0.002*
	Forward Inclination	11 (57.9)	143 (24.4)	
	Aft Inclination	3 (15.8)	64 (10.9)	
	Others	2 (10.5)	37 (6.3)	
Root apex completeness	Apical closure	19 (100.0)	503 (86.0)	0.379
	Apical patency	0 (0.0)	44 (7.5)	
	Unexploited apical (≧2/3)	0 (0.0)	16 (2.7)	
	Unexploited apical (<2/3)	0 (0.0)	22 (3.8)	
RS classification	Type I	2 (10.5)	143 (24.4)	0.002*
	Type II	2 (10.5)	170 (29.1)	
	Type III	9 (47.4)	217 (37.1)	
	Type IV	6 (31.6)	46 (7.9)	

	Type V	0 (0.0)	9 (1.5)	
Vertical relationship	Type A	0 (0.0)	102 (17.4)	<0.001*
	Type B	3 (15.8)	218 (37.3)	
	Type C	3 (15.8)	146 (25.0)	
	Type D	13 (68.4)	119 (20.3)	
Horizontal relationship	Type 1	6 (31.6)	203 (34.7)	0.688
	Type 2	7 (36.8)	247 (42.2)	
	Type 3	6 (31.6)	135 (23.1)	
Number of roots	One	18 (94.7)	446 (76.2)	0.134
	Two	0 (0.0)	94 (16.1)	
	Three	1 (5.3)	45 (7.7)	
Incision	No	1 (5.3)	266 (45.5)	<0.001*
	Yes	18 (94.7)	319 (54.5)	
Bone removal	No	3 (15.8)	341 (58.3)	<0.001*
	Yes	16 (84.2)	244 (41.7)	
Fracture of the maxillary tuberosity	No	19 (100.0)	577 (98.6)	1.000
	Yes	0 (0.0)	8 (1.4)	
Remarkable hemorrhage	No	17 (89.5)	579 (99.0)	0.024*
	Yes	2 (10.5)	6 (1.0)	

Table 4.

Variable	P value	Odds ratio	95% CI	
			Lower	Upper
RS classification Type III/IV	0.015	4.47	1.33	15.04
Vertical relationship Type D	0.002	5.63	1.89	16.71
One root	0.033	12.87	1.23	135.00
Pericoronitis	0.036	3.97	1.09	14.37
Bone removal	0.002	8.68	2.23	33.77
Remarkable hemorrhage	0.015	18.01	1.75	185.30

CI. Confidence interval