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RESEARCH ARTICLE

DISTRIBUTION OF IMPLANT FAILURE CAUSED BY POSITIONING IN A GROUP OF TURKISH PATIENTS ON CBCT

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ABSTRACT

Purpose: The aim of this report was to evaluate the prevalence of implant failure rates due to implant positioning on Cone Beam Computed Tomography.
Material and Methods: Study sample (n= 333) consisted of Cone Beam Computed Tomography (CBCT) scans of patients who were referred to the Department of Dentomaxillofacial Radiology, University of Health Sciences Turkey, Gülhane Faculty of Dentistry, Ankara, Turkey. Obtained data such as age, gender, number of implants and locations from CBCT images gathered and recorded. Data were initially analyzed by descriptive statistics. Kolmogorov Smirnov, Kruskal Wallis and Mann Whitney-U Tests were performed. We established the statistical significance (p<.05) with a 95 percent confidence interval.
Results: The data consists of 333 patients and so the total data evaluated was 844. The implant survival rate of the patients between 20-40 years old (49.4%) was lower significantly than that of the patients ≥ 40 years old (P=0.001). In the R4 (right mandibular region), implant failure rate is 17.5% shows quite low rate compared to other regions. At the R1 (right maxillary region) (39%) and R2 (45%) the most common reason of failure was maxillary sinus perforation, the least common reason was palatinal bone perforation, respectively 4% and 1%.
Conclusion: Preventing misinterpretations of clinicians is only possible by correct evaluation of incidental findings and better knowledge of head and neck anatomy.

Keywords: cbct, implant failure, incidentally findings

INTRODUCTION

International Organization for Standardization (ISO) defined dental implant as ‘a material which surgically placed to support prosthetic application in mandible or maxilla’ (1). Although elimination of dental deficiencies, aesthetic and function was reinstated to the patient with conventional prosthetic approaches, the implant system is considered as an alternative for individuals who do not prefer or may not be able to use conventional prosthetic therapy (2).

Dental implantology is accepted as an indispensable part of conventional practice, it is a great necessity to know the technics of implant imaging as well as patient selection.

Panoramic radiography is commonly preferred primarily in dental practice as a precious diagnostic tool. Despite its advantages, this two-dimensional imaging method has some disadvantages such as superimposition, distortion, low image quality, magnification and misinterpretation of structures (3,4). To overcome these problems, the first Cone

Beam Computed Tomography (CBCT) system was developed in the 1990s (3-6).

Clinicians can evaluate patients for several pathologies and structures by CBCT, it allows multiplanar visualization of the craniofacial structures. It provides significant and detailed information for orthodontics, endodontics, trauma, cysts or tumor assessment, teeth and Temporomandibular joint evaluation as well as dental implant procedure (4,7). Some pathologies or anatomic variations may be misdiagnosed due to two dimensioned imaging modalities' limitations. Another reason for misdiagnosis is that the most of clinicians do not care about the anatomical structures or pathologies outside of the regions of primary interest (4,7,8).

Comprehensive and detailed radiographic evaluation for diagnosis and treatment planning, should be applied using the appropriate radiologic modality (9). Mispositioned implants, proximity of implant to adjacent roots, neurovascular disturbances, perforation of some anatomical structures such as maxillary sinus nasopalatin canal or mandibular canal can be viewed clearly by CBCT. With regard to neurovascular disturbances, the most affected structures are mandibular canal and nasopalatine canal. These may cause serious hemorrhages and life-threatening airway obstructions. The most common causes of implant failure are insufficient distance between implants or adjacent teeth, and incorrect in implant positioning (10,11). Most failure cases occur in the maxilla (12).

In this study, we aimed to evaluate the rates and possible reasons of failure of implant therapy on CBCT in a group of Turkish patients which was obtained from a part of the society.

MATERIAL AND METHODS

This cohort and cross-sectional study is a retrospective. We used CBCT scans to evaluate the success of implants. The images used in the study were acquired on a 3D Accuitomo 170 (3D Accuitomo; J Morita Mfg. Corp., Kyoto, Japan) which were obtained between 2012-2017. The study sample (n= 333) consisted of CBCT scans of patients who were referred for CBCT evaluation to the Department of Dentomaxillofacial Radiology, University of Health Sciences Turkey, Gülhane Faculty of Dentistry, Ankara, Turkey.

This retrospective study was approved by the Gülhane Scientific Research Ethics Committee (Date: 17.06.2021; Decision: 2021/280). Before the examinations, the patients provided informed consent according to the principles of the Helsinki Declaration including all amendments and revisions. Collected data were only accessible to the researchers.

The practitioner that examines the images in the study only assessed the radiographs and were blinded to any other patient data in the radiographic examination procedure. All the CBCT images were evaluated by a dentomaxillofacial radiologist with over 10 years of experience. 333 of these scanned images were included in the study which were found to have implant treatment and required bone quality examination. Images with unacceptable diagnostic quality were excluded from the study. Axial, sagittal, coronal and cross-sectional images were reconstructed for all patients, and three-dimensional reconstructions were used when needed. For CBCT evaluations, proprietary manufacturer software (i-Dixel 2.0/One Data Viewer/One Volume Viewer; J Morita Mfg. Corp.) was used. Images were viewed in a dimly lit room on a 30inch Dell 3008WFP Flat Panel Monitor (Dell Inc., Round Rock, TX, USA) at a screen resolution of 1920x1200 pixels and 32-bit colour depth.

Patients who had previously undergone dental implant treatment were included in the study. Syndromic individuals, CBCT images with magnification or artifact were excluded from the study.

In these patients, varying numbers of implants were observed. Obtained data such as age, gender, number of implants and locations from CBCT images gathered and recorded. In addition, implants were evaluated whether they were ideal or not in the base of following guidelines (13,14);

a. The implant should be at least 1.5 mm away from the adjacent teeth.

b. The implant should be at least 3 mm away from an adjacent implant.

c. At least 1 mm inferior to the floor of the maxillary sinuses, nasal sinuses, incisive canal and other anatomic variations

d. Two millimeters superior to the mandibular canal (14).

In this study, an implant is marked as non-ideal if the implant or implants are caused perforation of any of the; maxillary sinus, nasal fossa, mental foramen, mandibular canal, vestibular perforation, lingual/palatinal perforation, nasopalatin canal, accessory canal; damage of the adjacent teeth; can be placed inadequate or wrong positioned. In our

Table 1. Ideal-failed implant distribution table by age range groups; Kruskal Wallis test results. Number of Ideal implants was significantly lower in the age group 20-40 (p=0,001). There was no significant difference between age groups with regard to the number of failed implant(p=0,360)

	The Number of Implants					The Number of Ideal Implants					The Number of Failed Implants					The Rate of Ideal Implants
	Ort.	**S.S**	**N**	**%***	**P**	**Ort.**	**S.S**	**N**	**%***	**P**	**Ort.**	**S.S**	**N**	**%***	**P**	
20-40	1,86	1,39	83	%9,8	0,001	0,95	1,588	41	%8,0	0,001	0,91	0,811	42	%12,6	0,360	%49,4
40-60	**2,42**	2,155	444	%52,6		1,5	1,758	273	%53,5		0,92	1,12	171	%51,2		%61,5
60-80	2,95	2,447	317	%37,6		1,81	1,85	196	%38,5		1,14	1,357	121	%36,2		%61,8
Total	2,52	2,197	844	%100,0		1,53	1,783	510	%100,0		0,99	1,219	334	%100,0		%60,4

Table 2. Ideal-failed implant distribution table by gender; Mann Whitney-U test results. There is no significant difference between gender groups with regard to the number of implemented implants (p=0,856), failed implants(p=0,512) and ideal implants(p=0,456)

	The Number of Implants					The Number of Ideal Implants					The Number of Failed Implants					The Rate of Ideal Implants
	Ort.	**S.S**	**N**	**%***	**P**	**Ort.**	**S.S**	**N**	**%***	**P**	**Ort.**	**S.S**	**N**	**%***	**P**	
20-40	1,86	1,39	83	%9,8	0,001	0,95	1,588	41	%8,0	0,001	0,91	0,811	42	%12,6	0,360	%49,4
40-60	**2,42**	2,155	444	%52,6		1,5	1,758	273	%53,5		0,92	1,12	171	%51,2		%61,5
60-80	2,95	2,447	317	%37,6		1,81	1,85	196	%38,5		1,14	1,357	121	%36,2		%61,8
Total	2,52	2,197	844	%100,0		1,53	1,783	510	%100,0		0,99	1,219	334	%100,0		%60,4

study implants that do not comply with the distance parameters given in 4 items above were evaluated as 'inadequate or wrong positioned'.

We evaluated the implants in four region; right maxillary, left maxillary, left mandibular and right mandibular. For ease of expression, we have codded these regions. According to FDI two-digit numbering systems for the teeth; we codded the right maxillary region as Region1 (R1), the left maxillary region as Region2 (R2), The left mandibular region as Region3 (R3) and the right mandibular region as Region4 (R4).

Data were initially analyzed by descriptive statistics. The occurrence rate of ideal and incidentally found implant failure was noted. Mean, distribution and range were used to describe the age, gender of the patients. Kolmogorov Smirnov, Kruskal Wallis and Mann Whitney-U Tests were performed using the IBM SPSS Statistics 21.0 (IBM Corp., Armonk, NY, USA) and MS Excel 2007. Kruskal Wallis Test is implemented in the groups more than 2 and for the data, which is not distributed normally. So we used Kruskal Wallis Test because the data of "failure rate of implants classified by age" satisfies these rules. Mann Whitney-U Test is generated because the data of "ideal and failed implants classified by gender and area" satisfies two independent and numeric characteristics. The data is not distributed normally. Therefore, we used Mann Whitney-U Test. We established the statistical significance (p<.05) with a 95 percent confidence interval.

RESULTS

The data consists of 333 patients; 179 female and 154 male. The number of implants in the patients varied, so the total data evaluated was 844 (# of implants implemented). Total mean age of patients (333 patients) is 53.29. Mean age of female and male are 52.99 and 53.64 respectively.

The number of implants between the ages of 20-40, 40-60 and 60-80 years were respectively; 83 (9.8%), 444 (52.6%) and 317 (37.6%). Total data failure rate is %39.6. The failure rate is evaluated within each age groups (20-40, 40-60, 60-80) respectively; 50.6%, 38.5%, 38.2% (Table 1; Kruskal Wallis test results). The implant survival rate of the patients between 20-40 years old (49.4%) was lower significantly than that of the patients ≥40 years old (P=0.001).

According to the statistical tests we found no significant difference in the number of implants between the groups formed according to the implanted area (p=0.950). There was no significant difference in terms of the number of implants between the groups formed by gender (p=0.856) and no significant difference in gender between the ideal and failed implants (respectively; p=0.456, p=0.512) (Table 2; Mann Whitney-U test results).

In our study group, the number of implants placed on the R1 was 197 and, 99 were considered as ideal. The rate of implant failure in the R1 is quite high as 50%. The number of implants placed on the R2 is 254 and the ideal number of implants is 114. Implant failure rate in this region was found to be 55.1%.

The number of ideal implants was significantly lower in the R2 group compared to the other groups (p=0.000). In the R4, implant failure rate is 17.5% shows quite low rate compared to other regions. Implant failure rate in the R3 was 30.1%.

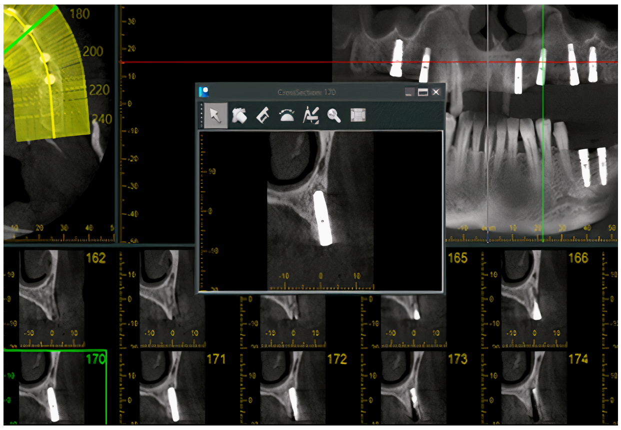

Figure 1. Inadequate or wrong positioning on left maxillary region on CBCT

We evaluated the distribution of implant failure reasons which were determined in our study group by region. 'Inadequate or incorrect positioning' was found as the most common cause of implant failure in the R4 (47%) and R3 (56%) (Figure 1).

However at the same region, among the 184 implants which were evaluated as failure there were no mental foramen perforation. The least common reason caused implant failure for both right and left regions was 'damage of adjacent teeth' (Figure 2).

At R1 (39%) and R2 (45%) the most common reason of failure was maxillary sinus perforation (Figure 3), the least common reason was palatinal bone perforation, respectively 4% and 1%. To be valid for both jaws; The implant failure rate was found to be higher on the left side than on the right side (Table 3; Distribution of failed implants by regions vs occurance reasons).

In general; the most common failure reasons were 'inadequate/incorrect positioning' and 'perforation of

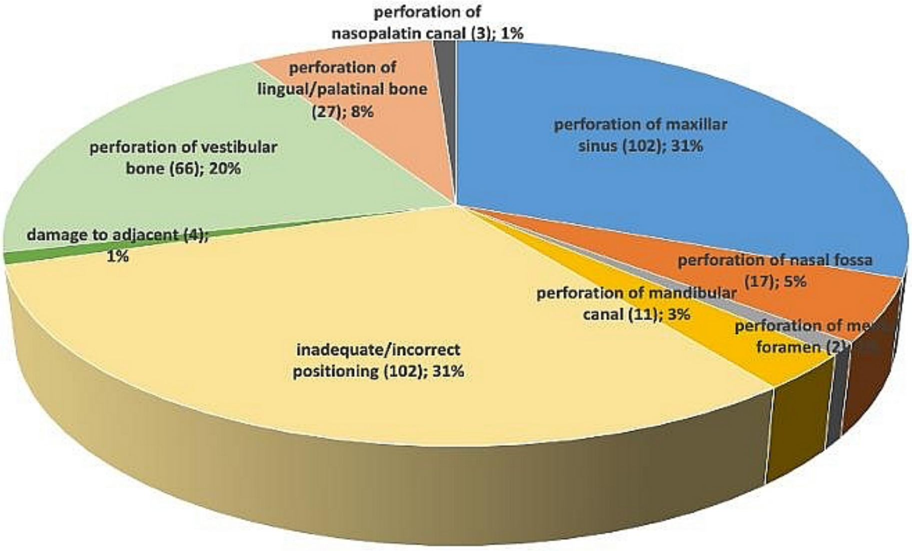

Figure 2. Distribution of failed implants by reasons

were 'perforation of nasopalatin canal' and 'damage to adjacent teeth' (Figure 2). 'Mandibular canal maxillary sinus'. The least common reasons of failure perforation' was seen at a rate of 3% (Figure 4). 'Perforation of accessory canal' wasn't seen on any region.

DISCUSSION

Diagnostic imaging is an essential component of treatment planning in oral rehabilitation using osseointegrated dental implants. Preoperative evaluation of anatomical structures, primarily neurovascular structures is critical to achieve success in implant treatment (15). To avoid possible complications, American Academy of Oral and Maxillofacial Radiology (AAOMR) suggests cross-sectional imaging in CBCT, for evaluation of the implant site in all implant planning (15). Therewithal as a result of the evaluations made by Benavides et al; If 3D (three dimension) imaging will make a significant contribution about the region that planning implant, CBCT must be considered (16).

Some authors have demonstrated that clinical examination and panoramic radiography alone may provide sufficient imaging for posterior mandibular implant placement (17,18), especially when there is a 2 mm margin of safety above the inferior alveolar canal (19). However, since the accuracy of the measurements taken on panoramic radiography is controversial, the value of 2 mm to be determined here will also be controversial. Therefore, no matter where, it will be more accurate to determine the implant locations and make measurements with CBCT before the implant planning.

Prashant and Sushma performed a study (20) about evaluation of imaging modalities according to some criteria with regard to dental implantology (bone height, bone width, long axis or ridge, anatomic localization, bone quality, pathology identification, jaw boundry identification, virtual planning, guide fabrication, communication aid, benefit/risk/cost ratio). Evaluated modalities were cephalometric, periapical, ortopantomograph, computerized tomography, cone-beam computerized tomography. Study showed that CBCT is the best radiological technic in point of dental implantology (20). Similarly Dreiseidler et al. (21) mentioned that diagnostic sensitivity and specificity levels of CBCT are as high as or higher than those obtained using other diagnostic methods.

In 2002 The European Association for Osseointegration reported some guidelines for the use of diagnostic imaging in implant dentistry (22). These guidelines in terms of pre-treatment 3D imaging (including cone beam computed tomography): (i) when clinical examination and conventional radiography is insufficient to evaluate the important anatomical structures, their locations and boundaries, (ii) when extensive bone augmentation is anticipated, (iii) for all sinus floor elevation procedures, (iv) for all guided implant surgery (computer-assisted planning and placement of dental implants) cases, (v) when further information regarding intraoral autogenous bone donor sites is needed, (vi) when planning the use of special surgical

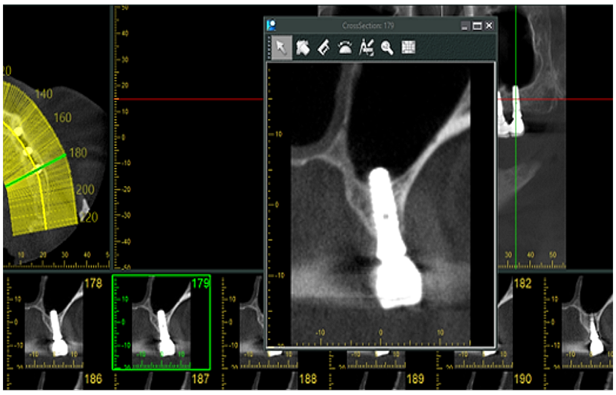

Figure 3. Maxillary sinus perforation on left maxillary region on CBCT

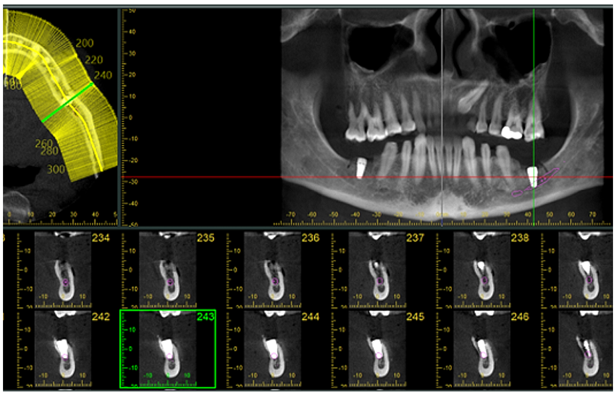

Figure 4. Mandibular canal perforation by implant on left mandibular region on CBCT

techniques, such as zygomatic implants or osteogenic distraction (23).

All the above mentioned literatures describe the validity of CBCT in the diagnosis before implant treatment. Today, CBCT technique is considered as a reliable imaging technique. We studied on CBCT images containing implants previously taken for different reasons and evaluated how ideal the implants were positioned in line with the parameters we determined.

Many studies on implant failure causes have been performed to date. Two of them evaluated the implant the failure rates in regard to the medical history of the patients, smoking status (24,25).

A similar study was made by Ribas et al. (10) similar parameters were used. It was found that most common failure reason is inadequate distance between implants or adjacent teeth. This parameter is expressed as wrong positioned in present study was also found to be the most common cause of failure in this study.

Another research study was performed in 2323 patients CBCT images. Complications related to implant positioning were the most common reason caused failure like the present study. Clerk et al. (11) revealed that the very popular implant treatment is not without risk and possible complications have very serious consequences.

As well as it was found that implant related perforations were mostly in the maxilla (12). Similarly, in this study the majority of failure cases were seen in the maxilla and in the R2 region, that is in the maxilla. The common cause of failure was the same in both studies; it was found as implant related perforation.

In another study it was evaluated, the anatomical structures' implant related perforation rates, whether the distance between implant and the adjacent tooth or implant was sufficient. These findings' associations were also assesseal. Perforation of anatomical structures was more common than the others in their study group. (12)

There are no studies in the literature comparing the rates of implant failure in 4 quadrants in the jaw (upper-lower) by evaluating the parameters we determined. These parameters can also be considered as implant treatment complications. With our retrospective study, implant failure or complication rates were evaluated comparatively in CBCT images in a group of Turkish population. The parameters we evaluate also provide information about the anatomy knowledge of physicians, their planning successes before treatment and hand capabilities. This study can also be defined as a research that reveals physicians performing implant treatment mostly in which region and depending on what they fail.

The studies performed in recent years have concluded that survival rates of implant treatment are very high (26-28). Balshi et al. (26) evaluated the survival rates of implants in mandible with 10 to 27 years of follow-up. They found a cumulative survival rate of 92.6%. As a result of this study; patient sex, age, degree of edentulism, location of implant, time of loading implant size and type, bone quality, prosthesis type didn't significantly affected the long-term implant survival rates (26). In the study performed by De Angelis et al. (28); the patients with implant treatment were evaluated which have risk factors like cigarette and bruxism, they found a success rate of 84%.

It's a significant point that survival and success are very different notions (29). We can define the survival as 'still in place', but it is not enough for success; must be healthy and fully functional in the oral cavity for a

Table 3. Distribution of failed implants by regions vs occurance reasons

Region	Perforation of maxillar sinus	Perforation of nasal fossa	Perforation of mental foramen	Perforation of mandibular canal
R4 (Right mandibula)	0 (0%)	0 (0%)	0 (0%)	4 (13%)
R1 (Right maxilla)	39 (39%)	9 (9%)	0 (0%)	0 (0%)
R3 (Left mandibula)	0 (0%)	0 (0%)	2 (3%)	7 (11%)
R2 (Left maxilla)	63 (45%)	8 (6%)	0 (0%)	0 (0%)
TOTAL	102 (31%)	17 (5%)	2 (1%)	11 (3%)
*number (ratio)				

successful treatment (29). Since our study was retrospective, it was not possible to evaluate whether the implants were functioning or not. So that in this study we accepted the survival as 'ideal'. Implant survival rate in the population we evaluated was 60.4%. Although 60.4% has a survival rate over 50% and this rate can be considered as high, but the failure rate cannot be considered low (39.6%).

Although the implant success and survival rates increased steadily, the failure and complications of implant treatment could not be completely eliminated. Periimplantitis is the most common cause of failure and secondly perforation of anatomic structures is seen frequently too and causes failure (30,31). Our study basically evaluated the perforation rates of the anatomical structures in the upper and lower jaw.

In maxilla one of the two major implant failure reason postoperatively is the maxillary sinus perforation. It was observed in a study that the incidence of sinus perforation reached %44 (32). This is not always a bad condition for dental implant and sinus (30). Mild perforations of maxillary sinus during implant treatment usually heal spontaneously and covered by normal mucoepiosteum (33). But mostly it may cause failure of implant and sinus infection (28,31). Misch and Ekfeldt et al evaluated that maxillary posterior region has the lowest bone density and the highest implant failure rate (34,35). Our study verified these findings; implant failure has been most common in the R2, the most common cause of failure in the maxilla was maxillary sinus perforation.

Another complication encountered in maxilla is nasal cavity penetration. Hsu and Wang reported a case in which an implant perforated the nasal floor, leading to a quasi-neoplastic lesion of the nasal cavity (36). A similar case was reported that the patient complained of uncomfortable altered nasal airflow after implant treatment. Radiographic examination showed that apical part of the dental implant placed in the maxillary anterior region had perforated the nasal floor and was partially penetrated into the nasal cavity (37). As seen in both cases, complications of the nasal cavity perforation can be very crucial and serious. Depending on the airflow obstruction, can also develop rhinosinusitis (38). According to our study results while the perforation of nasal fossa floor in R1 was at a rate of 9%, in R2 was at a rate of 6%. Although the failure rates are not too high, they are not negligible.

Another result of the study is about the relation between age and implant failure rates. We performed the statistical analyzes by dividing the age range into 3 groups (20-40, 40-60, 60-80). We found that the rate of implant failure decreased as the age range increased. This result may be related to the population we evaluated. While the implant failure rates of 40-60 and 60-80 age ranges not changing much, between the age of 20-40 the rate was significantly higher than the other two groups. Accordingly it is one of the possible results that it can be concluded it is more difficult for the dentist to work surgically during the implant treatment in patients between the ages of 20-40 for this study group.

Implants which are perforated nasopalatin canal can cause some complications such as hemorrhage during operation, short term sensory disturbances, lack of osseointegration of implant and nasopalatine duct cyst formation (37-40). According to our research the nasopalatine canal perforation is one of the less common failure reason of the implant treatment (Figure 2). In our study group there is no nasopalatine canal perforation in R1 and only 3 implants penetrated the nasopalatine canal in the R2. Although in the R1 and R2 implant failure rates are very close to each other, the ratio was lower in the R1. In the mandible, failure rate was lower on the R4. The most common implant failure reason in the mandible is 'inadequate or incorrect positioning'. According to the results of the study, although the survival rate in the right side of mandible is higher than the left side, lingual perforation, vestibular perforation, damage to the adjacent tooth and mandibular canal perforation are mostly observed in the right side. In the left side 'inadequate or incorrect positioning' was seen mostly. These results show that it can be said that it is more comfortable and easier to apply implant treatment for the right side of the mouth in the patient group in which we conduct the study.

Consequently, when there is no symptom, no need for 3D radiographic imaging to follow up. But CBCT may be supporting to the diagnosis and management of certain post-operative complications (41).

Preventing misinterpretations of clinicians is only possible by correct evaluation of incidental findings and better knowledge of head and neck anatomy (42). Defining the localization of accurate anatomical structures and anatomic variations will bring success in implant treatment.

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This study has some limitations. Firstly, as this study was performed retrospectively on CBCT images, it was not possible to evaluate the function of the implants. Also another limitation of CBCT is the presence of metal in the area to be scanned; in these cases, an artifact appears that impairs the image quality. In order to reduce the number of these artifacts, KIBT is still limited for early detection of implant failure, although certain techniques are used (42).

CONCLUSION

Preventing misinterpretations of clinicians is only possible by correct evaluation of incidental findings and better knowledge of head and neck anatomy (43). Defining the localization of accurate anatomical structures and anatomic variations will bring success in implant treatment.

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Author contributions: Conceps:Hilal Peker Ozturk; Data curation: Hilal Peker Ozturk, Ismail Hakan Avsever; Analysis: Hilal Peker Ozturk, Aslıhan Aslan Balcı, Hatice Seda Ozgedik, Bugra Senel, Merdan Allaberdiyev; Research: Hilal Peker Ozturk, Hatice Seda Ozgedik, Bugra Senel, Merdan Allaberdiyev; Methodology: Hilal Peker Ozturk, Hatice Seda Ozgedik; Writing - Original Draft: Hilal Peker Ozturk; Drafting - Revision And Editing: Hilal Peker Ozturk, Aslıhan Aslan Balcı, Bugra Senel, Merdan Allaberdiyev, Ismail Hakan Avsever

Conflict of interests: The authors declare that they have no competing interests. No funding to declare.

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