Original Article

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Dentistry Section

Prevalence of Dental Implant Positioning Errors among the Saudi Arabian Population: A Retrospective Observational Study

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ABSTRACT

Introduction: Despite being an established procedure with a success rate exceeding 90%, dental implant therapy can be associated with certain complications, such as peri-implantitis and mechanical failures. Among the factors contributing to implant failure, implant placement-related factors may play a crucial role; however, their prevalence has been less frequently reported in the scientific literature.

Aim: To assess the prevalence of errors in dental implant placement using Orthopantomogram (OPG) records of patients.

Materials and Methods: A retrospective observational study was conducted in the Dental Clinics at Al Zulfi, College of Dentistry, Majmaah University, Al-Majmaah, Riyadh Province, Saudi Arabia from August 2013 to June 2023. Approximately 500 records of patients who had received atleast one dental implant were reviewed. Data regarding gender, type of implant, and implant position (anterior vs posterior; maxilla vs mandible) were collected. Implant placement errors, such as violation of the minimum distance between two implants (<3 mm) or between a tooth and an implant (<1.5 mm), as well as thread exposure, were assessed on OPGs by three independent investigators. Other factors associated with implant positioning errors were also evaluated. The Chi-square test was used to determine significant differences between implant positioning errors and implant location.

Results: The study included 147 participants with a total of 500 dental implants, of whom 116 (78%) were male and 31 (22%) were female. A total of 348 implants (69.6%) exhibited placement errors. Implants placed in the maxillary arch showed a significantly higher prevalence of violation of the minimum distance between the implant and the tooth compared to those placed in the mandibular arch ($p<0.05$). Conversely, implants placed in the mandibular arch had a higher incidence of thread exposure compared to those in the maxillary arch ($p<0.05$).

Conclusion: Successful dental implant therapy depends on multiple factors, including patient selection, meticulous treatment planning, precise surgical technique, prosthetic design, and long-term maintenance.

Keywords: Diagnostic imaging, Orthopantomogram, Panoramic radiography

INTRODUCTION

Edentulism is considered a common public health problem that significantly affects individuals' well-being and quality of life [1]. Several treatment modalities are available for patients with complete or partial edentulism. Among these, dental implant therapy is regarded as a well-established treatment procedure, primarily due to the functional and aesthetic benefits it provides [2]. Dental implants, along with prosthetic restorations, offer superior functional and aesthetic outcomes compared to other rehabilitative treatments [3].

Despite being a well-established procedure with a success rate exceeding 90%, dental implants are not without complications, such as lack of osseointegration, peri-implantitis, and implant fracture [4]. These complications are believed to arise mainly from host-related, surgery-related, and implant placement-related factors [5]. Host-related factors include systemic illnesses, advanced age, and poor oral hygiene. Surgery-related factors depend largely on the clinician's skill and experience, while placement-related factors typically involve errors in implant positioning [6].

Host-related factors are largely non modifiable and consistently influence implant success; hence, careful patient selection plays a vital role in minimising the risk of implant failure. Surgery-related factors, on the other hand, depend on the operator's expertise, which can be improved through continuous professional training to reduce implant failures.

In contrast, implant placement-related factors are less frequently discussed in the scientific literature. Several recent cross-sectional studies using Computed Tomography (CT) have evaluated the prevalence of dental implant positioning errors, concluding that thread exposure, contact of the implant with anatomical structures, and violations of the recommended distances between teeth and implants, as well as between two implants, are the most common positioning errors [6,7]. As most of these studies relied on CT analysis, further research using alternative diagnostic techniques is warranted to obtain more representative data. Therefore, the present study aimed to assess the prevalence of implant placement errors using OPG records of patients who received dental implants.

MATERIALS AND METHODS

A retrospective observational study was conducted in the Dental Clinics at Al Zulfi, College of Dentistry, Majmaah University, Al-Majmaah, Riyadh Province, Saudi Arabia from August 2013 to June 2023. The study protocol was approved by the Institutional Review Board (Reference No: MUREC-Sep.25/COM-2023/29-1). Permission to collect data from archived records was obtained from the Division Head, Medical Records Section.

Sample size calculation: The sample size for present study was calculated based on the prevalence of positioning errors in dental implant placement reported in previous research. Assuming a Type I error probability of 5%, an allowable error of 15%, and an estimated prevalence of 45% [8], the required sample size was determined to be 460. To account for potential measurement or radiographic errors, the sample size was increased to 500. Records were selected using a consecutive sampling method.

Inclusion criteria:

- Patients who had received atleast one dental implant in the past.
- Patients with complete medical and dental records, including an available Orthopantomogram (OPG).

Exclusion criteria:

- Patients who did not provide consent for the use of their medical records for research purposes.
- Records with unclear or poor-quality OPGs that hindered accurate data extraction.

Study Procedure

Data were collected by three trained investigators. Training was provided by a senior prosthodontist using clinical vignettes. Following the training session, interobserver reliability was assessed using a set of 15 orthopantomograms to ensure consistency among investigators. Intraexaminer reliability was evaluated using a random sample of dental records after two weeks, during which the same investigator re-evaluated the OPGs. Interexaminer reliability values ranged between 0.81 and 0.87, while intraexaminer reliability values ranged between 0.89 and 0.92, indicating high consistency.

The data related to following variables were recorded in a special format designed for this purpose: gender, type of implant, position of the implant (Anterior Vs Posterior; Maxilla Vs Mandible), surgical errors including violation of minimal distance between two implants (> 3mm or < 3mm) or between a tooth (>1.5 mm or <1.5 mm) and an implant and thread exposure. Further, prosthetic errors including increased crown height space (>12 mm), increased crown-implant ratio (above 1:1), splinting of implant to natural teeth (Yes Vs No), cantilevered implant crown (Yes Vs No), poor emergence profile (Yes Vs No), open contact areas (Yes Vs No) and increased crown angulation (>15°) were recorded. The values used as criteria for analysing the OPGs were obtained by using threshold values consistent with prior studies [9-13]. The software tools from Excellence in Administration, Clinical and Technology (EXACT) Dental Software (Henry Schein Inc., USA) were used to measure distances. Lastly, the data related to contact of the implant to any of the anatomical structures, such as the maxillary sinus, the nasal floor, and the mandibular canal, were recorded.

STATISTICAL ANALYSIS

Descriptive statistics were calculated and expressed as mean, standard deviation, percentage, and frequency. Comparisons were made and tested for statistical significance using the Chi-square test. All analyses were performed using Statistical Packages of Social Sciences (SPSS) software (version 19.0, IBM Corp., Chicago, USA). A p-value of <0.05 was considered statistically significant.

RESULTS

The study was conducted among 147 participants who collectively had 500 dental implants, of which 116 (78%) were males. The average number of implants per participant was 3.4±3.04. Out of the 246 implants placed in the maxillary arch, 186 (75.61%) were placed in the posterior region. Similarly, among the 254 implants placed in the mandibular arch, 223 (87.7%) were placed in the posterior region [Table/Fig-1]. Nearly 91.8% of the implants were two-piece systems. Of the total implants assessed, 18 implants were found to be violating adjacent anatomical structures [Table/Fig-1]. Total 16 encroached upon the maxillary sinus, and one each violated the nasal floor and inferior alveolar canal [Table/Fig-2,3].

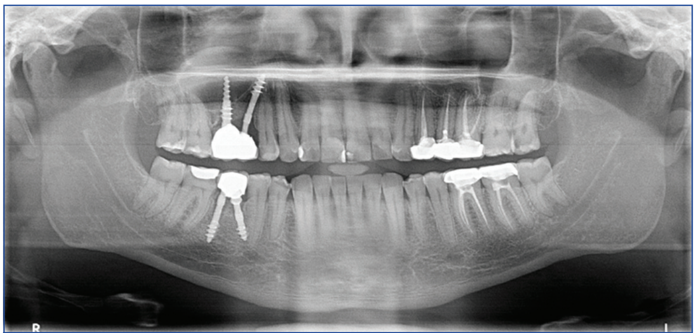
The distribution of various types of implant placement errors in the anterior and posterior regions of the maxillary and mandibular arches is presented in [Table/Fig-4]. Violation of the minimum distance between implants or between an implant and an adjacent tooth [Table/Fig-5] was more prevalent in the maxillary arch, whereas exposure of implant threads [Table/Fig-6], placement of cantilevered implants [Table/Fig-7], and poor emergence profiles [Table/Fig-8] were more frequently observed in the mandibular arch.

The occurrence of various implant placement errors varied according to the region in which the implant was placed, as shown in [Table/Fig-9]. Violation of the minimum distance between two implants, absence of prosthesis, and increased crown angulation (>15°) [Table/Fig-10] were more frequent in the maxillary anterior region.

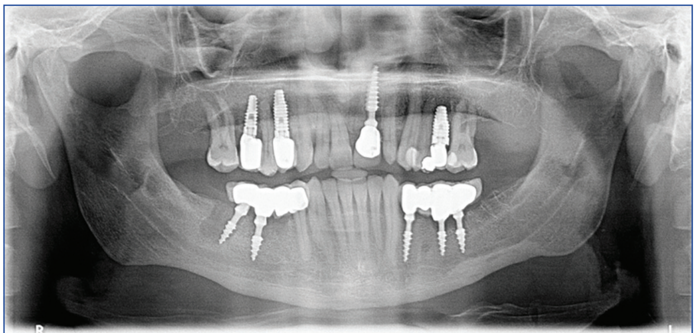
In contrast, exposure of implant threads, open contact areas [Table/Fig-11], increased crown-to-implant ratio [Table/Fig-12], and poor emergence profile were more prevalent among single-piece

Parameters	Male n (%)	Female n (%)	Total
Subjects	116 (78.23)	31 (21.09)	147
Implants	426 (85.2)	74 (14.8)	500
Total implants observed with errors = 348 (69.6)			
Maxilla n (%)		Mandible n (%)	
Without errors/ complications	Errors/ complications	Without errors/ complications	Errors/ complications
80 (32.5)	166 (67.5)	72 (28.3)	182 (71.7)
Maxillary anterior		Mandibular anterior	
Without errors/ complications	Errors/ complications	Without errors/ complications	Errors/ complications
23 (38.3)	37 (61.7)	7 (22.6)	24 (77.4)
Maxillary posterior		Mandibular posterior	
Without errors/ complications	Errors/ complications	Without errors/ complications	Errors/ complications
57 (30.6)	129 (69.4)	65 (29.1)	158 (70.9)
Violation of adjacent anatomical structures			
Maxillary sinus	Nasal floor	Inferior-alveolar canal	Mental foramen
16	1	1	0

[Table/Fig-1]: Descriptive data of implant errors distribution according to gender and location.
*n: Number of subjects



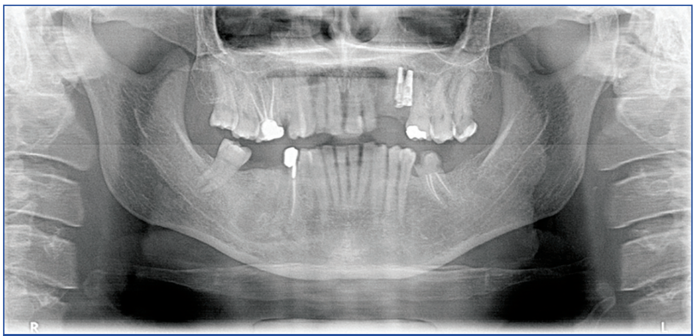
[Table/Fig-2]: The OPG showing one-piece implant placed within the maxillary sinus region and also violation of implant-tooth distance seen in both arches (<1.5 mm).



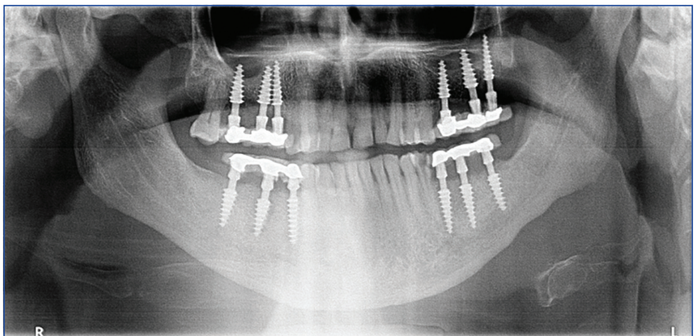
[Table/Fig-3]: The OPG showing a one-piece implant placed violating the nasal floor region and also improper seating of the implant abutment in the 25 region.

Type of defect	Maxillary anterior (n=60)		Maxillary posterior (n=186)		Mandibular anterior (n=31)		Mandibular posterior (n=223)	
	Well positioned n (%)	Poorly positioned n (%)	Well positioned n (%)	Poorly positioned n (%)	Well positioned n (%)	Poorly positioned n (%)	Well positioned n (%)	Poorly positioned n (%)
Violation in minimum distance between implants (<3 mm)	49 (81.7)	11 (18.3)	151 (81.2)	35 (18.8)	25 (80.6)	6 (19.4)	204 (91.5)	19 (8.5)
Violation of minimum distance between tooth and implant (<1.5 mm)	48 (80)	12 (20)	136 (73.1)	50 (26.9)	31 (100)	0	200 (89.7)	23 (10.3)
Exposure of implant thread	45 (75)	15 (25)	131 (70.4)	55 (29.6)	16 (51.6)	15 (48.4)	128 (57.4)	95 (42.6)
Implants without prosthesis	51 (85.0)	9 (15.0)	158 (84.9)	28 (15.1)	24 (77.4)	7 (22.6)	203 (91)	20 (9)
Implant body fracture	60 (100)	0	184 (98.9)	2 (1.1)	31 (100)	0	221 (99.1)	2 (0.9)
Increased crown height space (>12 mm)	43 (71.7)	17 (28.3)	135 (72.6)	51 (27.4)	16 (51.6)	15 (48.4)	146 (65.5)	77 (34.5)
Increased crown-implant ratio (above 1:1)	41 (68.3)	19 (31.7)	116 (62.4)	70 (37.6)	17 (54.8)	14 (45.2)	142 (63.7)	81 (36.3)
Prosthetic fracture	60 (100)	0	185 (99.5)	1 (0.5)	31 (100)	0	222 (99.6)	2 (0.4)
Implant splinted with natural tooth	57 (95.0)	3 (5.0)	176 (94.6)	10 (5.4)	28 (90.3)	3(9.7)	206 (92.4)	17 (7.6)
Cantilevered implant crown	59 (98.3)	1 (1.7)	181 (97.3)	5 (2.7)	29 (93.5)	2 (6.5)	209 (93.7)	14 (6.3)
Poor emergence profile	36 (60.0)	24 (40.0)	97 (52.2)	89 (47.8)	12 (38.7)	19 (61.3)	109 (48.9)	114 (51.1)
Crown/abutment not fully seated	57 (95.0)	3 (5.0)	162 (87.1)	24 (12.9)	27 (87.1)	4 (12.9)	190 (85.2)	33 (14.8)
Open contact area	54 (90.0)	6 (10.0)	178 (95.7)	8 (4.3)	24 (77.4)	7 (22.6)	209 (93.7)	14 (6.3)
Increased crown angulation (>15°)	56 (93.3)	4 (6.7)	185 (99.5)	1 (0.5)	31 (100)	0 (0.0)	220 (98.7)	3 (1.3)

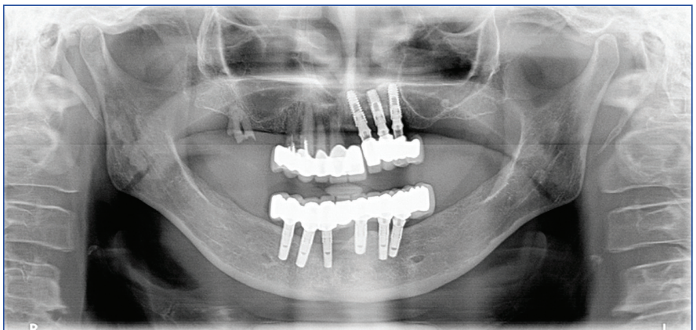
[Table/Fig-4]: Distribution of various types of defects/implant failures in maxillary and mandibular arch.



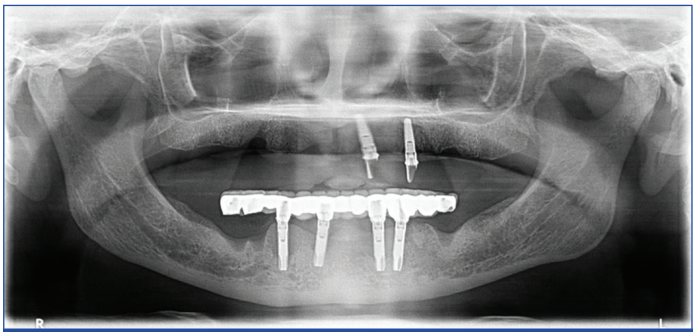
[Table/Fig-5]: Orthopantamogram (OPG) of study subject with violation of implant-tooth (<1.5 mm) and implant-implant (<3 mm) distance in the maxillary arch.



[Table/Fig-8]: Orthopantamogram (OPG) of study subject showing poor emergence profile both in the maxillary and mandibular arches.



[Table/Fig-6]: Orthopantamogram (OPG) of study subject thread exposure in the mandibular arch.



[Table/Fig-7]: Orthopantamogram (OPG) showing cantilevered implant bridge in the mandibular arch.

implants compared to two-piece implants, and this difference was statistically significant ($p<0.05$) [Table/Fig-13].

DISCUSSION

The present study evaluated a total of 500 dental implants and found that the overall prevalence of implant placement errors was 69.6%. In comparison, Rizzo G et al., [6] and Ribas BR et al., [7] reported higher prevalence rates of 74.4% and 82.9%, respectively. Conversely, Clark D et al., [9] found a much lower prevalence of implant positioning–related complications, approximately 7%. Such contrasting results among studies suggest that more robust evidence is needed to accurately determine the true prevalence of implant placement errors.

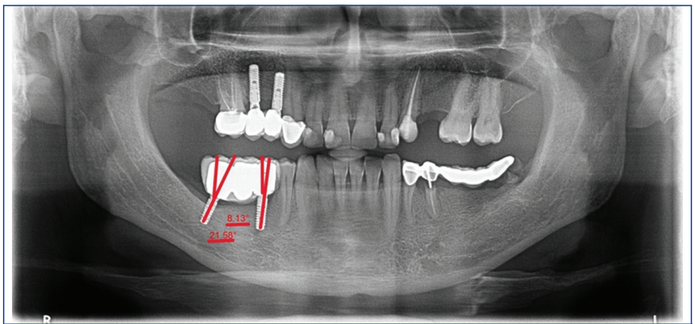
Furthermore, previous studies assessing implant positioning errors did not comprehensively include all types of potential errors. The present study addressed this gap by evaluating a wider range of implant placement errors and analysing their distribution based on the region of placement and type of implant.

Future research involving larger sample sizes, multicentre data, and standardised radiographic evaluation protocols is required to gain a deeper understanding of the factors influencing implant positioning errors and their clinical implications.

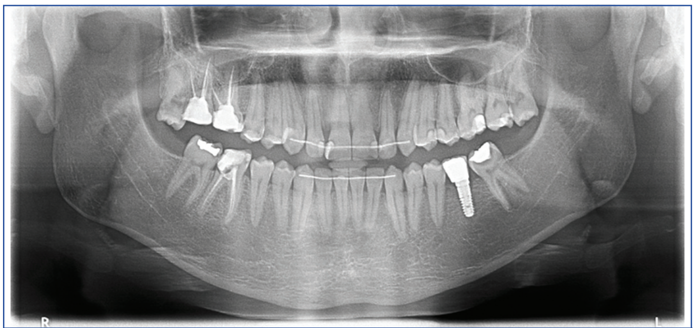
Arising mainly from positioning errors, the emergence profile was also assessed in the study. Interestingly, about 60% of the implants exhibited a poor emergence profile, with a higher prevalence

Condition/Error type	Maxillary anterior (n=60)	Maxillary posterior (n=186)	Mandibular anterior (n=31)	Mandibular posterior (n=223)	Total (N=500)	p-value
	n (%)	n (%)	n (%)	n (%)	N (%)	
Violation in minimum distance between implants (< 3 mm)	11 (18.3)	35 (18.8)	6 (19.4)	19 (8.5)	71 (14.2)	0.014*
Violation of minimum distance between tooth and implant (<1.5 mm)	12 (20.0)	50 (26.9)	0	23 (10.3)	85 (17.0)	0.001*
Exposure of implant thread	15 (25.0)	55 (29.6)	15 (48.4)	95 (42.6)	180 (36.0)	0.005*
Implants without prosthesis	9 (15.0)	28 (15.1)	7 (22.6)	20 (9.0)	64 (12.8)	0.082
Implant body fracture	0	2 (1.1)	0	2 (0.9)	4 (0.8)	0.816
Increased crown height space (>12 mm)	17 (28.3)	51 (27.4)	15 (48.4)	77 (34.5)	160 (32.0)	0.084
Increased crown-implant ratio (above 1:1)	19 (31.7)	70 (37.6)	14 (45.2)	81 (36.3)	184 (36.8)	0.639
Prosthetic fracture	0	1 (0.5)	0	1 (0.4)	2 (0.4)	0.926
Implant splinted with natural tooth	3 (5.0)	10 (5.4)	3 (9.7)	17 (7.6)	33 (6.6)	0.669
Cantilevered implant crown	1 (1.7)	5 (2.7)	2 (6.5)	14 (6.3)	22 (4.4)	0.209
Poor emergence profile	24 (40.0)	89 (47.8)	19 (61.3)	114 (51.1)	246 (49.2)	0.230
Crown/abutment not fully seated	3 (5.0)	24 (12.9)	4 (12.9)	33 (14.8)	64 (12.8)	0.254
Open contact area	6 (10.0)	8 (4.3)	7 (22.6)	14 (6.3)	35 (7.0)	0.002*
Increased crown angulation (>15°)	4 (6.7)	1 (0.5)	0	3 (1.3)	8 (1.6)	0.008*

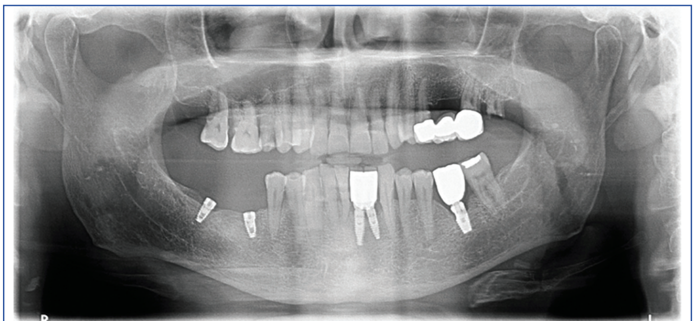
[Table/Fig-9]: Comparison of various types of surgical and prosthetic failures in implants placed in maxillary and mandibular arches based on position.
Chi-square test; *p-value<0.05 statistically significant



[Table/Fig-10]: Orthopantamogram (OPG) showing mandibular dental implant prosthesis with crown angulation >15° on the most distal implant.



[Table/Fig-11]: Orthopantamogram (OPG) showing open contact in the distal aspect of dental implant prosthesis in the mandibular arch.



[Table/Fig-12]: Orthopantamogram (OPG) showing increased crown-height space (>12mm) and crown to implant ratio more than 1 in the mandibular arch.

observed in the mandibular arch. Recent evidence suggests that a poor emergence profile plays a crucial role in the progression of peri-implant diseases [14]. The likelihood of thread exposure increases when the implant placement depth is unsatisfactory, particularly in areas with scant or keratinized mucosa [15]. Several studies have demonstrated an association between positioning errors and thread exposure [7,16]. However, in addition to positioning errors, factors such as poor oral hygiene, peri-implantitis, and loss of bone covering the implant can also contribute to thread exposure [17]. Furthermore, trauma caused by a supporting prosthesis may result in implant thread exposure [18].

The present study's findings contrast with those of Silva JA et al., [19], who reported a higher incidence of thread exposure in the maxillary anterior region. In contrast, present study found a higher prevalence in the mandibular region. It is noteworthy, however, that the prevalence of thread exposure was 37.5% in Silva JA et al.'s study [19], whereas it was 36% in the current study.

Maintaining an appropriate crown-to-implant ratio is essential for the even distribution of masticatory forces between the abutment and the implant. When this ratio is not maintained, it may result in a bending effect, generating excessive forces on the implant-abutment connection and marginal bone, potentially leading to adverse outcomes [20]. While previous studies assessed the crown-to-implant ratio using finite element analysis [20], present study is among the few to directly evaluate the prevalence of increased crown-to-implant ratios using radiographs. Finite element analyses have indicated that a high crown height space is a major factor contributing to stress generation in the marginal bone area. Anatomical measurements, including the apex-to-shoulder distance of the implant and the shoulder-to-crown end distance, were used to determine these ratios and crown height spaces. Hingsammer L et al., [21] concluded that a crown-to-implant ratio of 1.7 could be considered a threshold to prevent early marginal bone changes.

A distance of less than 3 mm between two implants or less than 1.5 mm between an implant and an adjacent tooth is considered a violation in implant positioning [6,7]. Such violations can cause hypersensitivity in adjacent natural teeth, food impaction, and eventually thread exposure [22,23]. Some studies have also shown that these violations can lead to bone resorption [24-26]. The findings of the present study regarding implant distance violations are consistent with the studies conducted by Ribas BR et al., [7], Tarnow D et al., [27], and Gaêta-Araujo H et al., [22], which reported that violations in implant-tooth distance were more frequent in the maxillary anterior region. This could be due to insufficient mesiodistal space between missing teeth. In such cases, platform-switching implants can be used, allowing placement as close as 1 mm to adjacent teeth without causing crestal bone changes [28].

Condition/Error type	One-piece implant (n=41)	Two-piece implant (n=459)	p-value
	n (%)	n (%)	
Violation in minimum distance between implants (< 3 mm)	2 (4.9)	69 (15.0)	0.074
Violation of minimum distance between tooth and implant (<1.5 mm)	7 (17.1)	78 (17.0)	0.99
Exposure of implant thread	11 (26.8)	169 (36.8)	0.202
Implants without prosthesis	2 (4.9)	62 (13.5)	0.113
Implant body fracture	1 (2.4)	3 (0.7)	0.219
Increased crown height space (>12 mm)	11 (26.8)	149 (32.5)	0.459
Increased crown-implant ratio (above 1:1)	27 (65.9)	157 (34.2)	0.001*
Prosthetic fracture	0	2 (0.4)	0.672
Implant splinted with natural tooth	3 (7.3)	30 (6.5)	0.847
Cantilevered implant crown	0	22 (4.8)	0.152
Poor emergence profile	33 (80.5)	213 (46.4)	0.001*
Crown/abutment not fully seated	4 (9.8)	60 (13.1)	0.543
Open contact area	5 (12.2)	30 (6.5)	0.174
Increased crown angulation (>15°)	1 (2.4)	7 (1.5)	0.655

[Table/Fig-13]: Comparison of prevalence of various types of implant failure based on type of implant.
Chi-square test; *p-value<0.05 statistically significant

Implant contact with adjacent anatomical structures such as the maxillary sinus, inferior alveolar nerve, or nasal cavity is another common positioning error observed in clinical practice [6]. In a retrospective study by Rizzo G et al., [6], implant contact with anatomical structures was the second most common positioning error and was significantly associated with the maxillary posterior region. Implant placement in the maxillary arch is more technique-sensitive due to the proximity of various anatomical structures, including the maxillary sinus, nasal cavity, and nasopalatine canal [6]. Therefore, clinicians must accurately interpret diagnostic images and plan treatments carefully to prevent implant perforations. However, due to the two-dimensional imaging used in the present study, violations involving adjacent anatomical structures such as the nasal floor, maxillary sinus, inferior alveolar canal, and nasopalatine canal could not be verified.

In present study, the prevalence of cantilevered dental implant prostheses was higher in the mandibular arch than in the maxilla. Typically, two implants are placed to replace two missing teeth. However, in cases where space is limited or bone volume is inadequate, cantilevered implant crowns are sometimes used, following recommended clinical guidelines [29]. Such restorations may lead to force overload, resulting in technical and biological complications [29]. Van Nimwegen WG et al., reported in their systematic review that approximately 95-100% of cantilevered implant crowns survived for up to four years [30]. However, the review also noted frequent technical complications in the posterior regions [30]. Similarly, the present study observed a greater number of cantilevered implant crowns in posterior teeth compared to anterior teeth.

Another prosthetic parameter evaluated in present study was the presence of open contact areas between implant prostheses and adjacent teeth or prostheses. It was observed that open contact areas were more prevalent in the mandibular posterior region, and this finding was statistically significant ($p<0.05$). Open contacts between an implant prosthesis and an adjacent tooth/prosthesis may result in food impaction, peri-implant disease, dental caries, and pathological tooth migration [31].

One-piece dental implants were introduced to simplify the conventional two-step implant placement procedure and improve treatment efficiency [32]. A systematic review and meta-analysis comparing the survival rates of one-piece and two-piece implants found no significant difference in survival rates or marginal bone loss between the two types [32]. In the present study, implant positioning errors were compared between one-piece and two-piece implants, and significant differences ($p<0.05$) were observed, particularly regarding increased crown-to-implant ratios and poor emergence profiles.

Cone Beam Computed Tomography (CBCT) provides three-dimensional imaging, allowing enhanced magnification and differentiation between soft tissues. However, CBCT has limitations such as image artifacts that can obscure the visualisation of osseointegration and peri-implant bone [6,8]. Additionally, CBCT is not universally available, and its use may restrict sample size due to limited imaging data during patient follow-up. For these reasons, OPG was preferred over CBCT in the present study.

Although implant positioning errors may contribute to implant failure, they cannot be considered a direct cause. Implants are deemed failed only when they are lost or require replacement [8]. Therefore, other clinical factors such as patient age, gender, implant type, and bone quality also play critical roles in determining implant success or failure [8]. Future prospective studies are needed to elucidate the relationship between implant positioning errors and implant failure by correlating them with clinical outcomes.

Limitation(s)

The present study has several limitations, including the use of secondary data and the absence of clinical factors influencing implant failure, such as the surgical protocol followed, the surgeon's experience, and the prosthetic loading protocol. Additionally, midline structures such as anterior implants and the nasopalatine canal or nasal cavity could not be accurately evaluated due to superimposition in radiographic imaging.

CONCLUSION(S)

Successful dental implant therapy depends on multiple factors, including patient selection, treatment planning, prosthetic design, and long-term maintenance. Implant malpositioning can lead to complications and implant-associated problems that may not be immediately evident. The high prevalence of positioning errors observed underscores the importance of careful patient selection and evidence-based treatment planning to achieve optimal outcomes.

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Authors' Contributions: All authors contributed equally to the study.

REFERENCES

[1] Emami E, de Souza RF, Kabawat M, Feine JS. The impact of edentulism on oral and general health. Int J Dent. 2013;2013:498305.
[2] Romanos GE, Delgado-Ruiz R, Sculean A. Concepts for prevention of complications in implant therapy. Periodontol 2000. 2019;81(1):07-17.
[3] Pjetursson BE, Heimisdottir K. Dental implants – are they better than natural teeth? Eur J Oral Sci. 2018;126(S1):81-87.
[4] Buser D, Mericske-Stern R, Bernard JP, Behneke A, Behneke N, Hirt HP, et al. Long-term evaluation of non-submerged ITI implants. Part 1: 8-year life table analysis of a prospective multicenter study with 2359 implants. Clin Oral Implants Res. 1997;8(3):161-72.
[5] Raikar S, Talukdar P, Kumari S, Panda SK, Oommen VM, Prasad A. Factors affecting the survival rate of dental implants: A retrospective study. J Int Soc Prev Community Dent. 2017;7(6):351-55.
[6] Rizzo G, Prado MC, Rigo L. Prevalence of dental implant positioning errors: A cross-sectional study. Imaging Sci Dent. 2022;52(4):343-50.
[7] Ribas BR, Nascimento EH, Freitas DQ, Pontual AA, Pontual ML, Perez DE, et al. Positioning errors of dental implants and their associations with adjacent structures and anatomical variations: A CBCT-based study. Imaging Sci Dent. 2020;50(4):281-88.
[8] Alaqeely R, Albaiz A, Alenazi B, Alem M, Alotaibi Y, Alrowis R. Prevalence of dental implant positioning errors: A radiographic analysis. J Clin Med. 2025;14(9):3221.
[9] Clark D, Barbu H, Lorean A, Mijiritsky E, Levin L. Incidental findings of implant complications on post-implantation CBCTs: A cross-sectional study. Clin Implant Dent Relat Res. 2017;19(5):776-82.
[10] Greenstein G, Cavallaro J, Tarnow D. Dental implantology: Numbers clinicians need to know. Compend Contin Educ Dent. 2019;40(5):e1-e26.
[11] Chethan KN, Eram A, Shetty N, Shetty DD, Futane M, Keni LG. Evaluating angled abutments: Three-dimensional finite element stress analysis of anterior maxillary implants. Prosthesis. 2024;6(2):315-28.
[12] Garaicoa-Pazmiño C, Suárez-López del Amo F, Monje A, Catena A, Ortega-Oller I, Galindo-Moreno P, et al. Influence of crown/implant ratio on marginal bone loss: A systematic review. J Periodontol. 2014;85(9):1214-21.
[13] Sanz M, Naert I; Working Group 2. Biomechanics/risk management (Working Group 2). Clin Oral Implants Res. 2009;20(Suppl 4):107-11.
[14] Mancini L, Thoma DS, Marchetti E, Jung RE, Strauss FJ. The 3D emergence profile on implant-supported restorations: A method for evaluating restorative angles. J Esthet Restor Dent. 2023;35(8):1264-70.
[15] Chung DM, Oh TJ, Shotwell JL, Misch CE, Wang HL. Significance of keratinized mucosa in maintenance of dental implants with different surfaces. J Periodontol. 2006;77(8):1410-20.
[16] Figuero E, Graziani F, Sanz I, Herrera D, Sanz M. Management of peri-implant mucositis and peri-implantitis. Periodontol 2000. 2014;66(1):255-73.
[17] Wang WC, Lagoudis M, Yeh CW, Paranhos KS. Management of peri-implantitis - a contemporary synopsis. Singap Dent J. 2017;38:08-16.
[18] Sakka S, Baroudi K, Nassani MZ. Factors associated with early and late failure of dental implants. J Investig Clin Dent. 2012;3(4):258-61.
[19] Silva JA, Alencar AH, Rocha SS, Lopes LG, Estrela C. Three-dimensional image contribution for evaluation of operative procedural errors in endodontic therapy and dental implants. Braz Dent J. 2012;23(2):127-34.
[20] Da Rocha Ferreira JJ, Machado LF, Oliveira JM, Ramos JC. Effect of crown-to-implant ratio and crown height space on marginal bone stress: A finite element analysis. Int J Implant Dent. 2021;7(1):01-05.
[21] Hingsammer L, Watzek G, Pommer B. The influence of crown-to-implant ratio on marginal bone levels around splinted short dental implants: A radiological and clinical short-term analysis. Clin Implant Dent Relat Res. 2017;19(6):1090-98.
[22] Gaêta-Araujo H, Oliveira-Santos N, Mancini AX, Oliveira ML, Oliveira-Santos C. Retrospective assessment of dental implant-related perforations of relevant anatomical structures and inadequate spacing between implants/teeth using cone-beam computed tomography. Clin Oral Investig. 2020;24(9):3281-88.
[23] Camargo IB, Van Sickels JE. Surgical complications after implant placement. Dent Clin North Am. 2015;59(1):57-72.
[24] Scarano A, Assenza B, Piattelli M, Thams U, San Roman F, Favero GA, et al. Interimplant distance and crestal bone resorption: A histologic study in the canine mandible. Clin Implant Dent Relat Res. 2004;6(3):150-56.
[25] Lops D, Mosca D, Müller A, Rossi A, Rozza R, Romeo E. Management of peri-implant soft tissues between tooth and adjacent immediate implant placed into fresh extraction single socket: A one-year prospective study on two different types of implant-abutment connection design. Minerva Stomatol. 2011;60(9):403-15.
[26] Wang T, De Kok IJ, Zhong S, Vo C, Mendonça G, Nares S, et al. The role of implant-tooth distance on marginal bone levels and esthetics. Int J Oral Maxillofac Implants. 2019;34(2):499-505.
[27] Tarnow D, Cho SC, Wallace SS. The effect of inter-implant distance on the height of inter-implant bone crest. J Periodontol. 2000;71(4):546-49.
[28] Gupta S, Sabharwal R, Nazeer J, Taneja L, Choudhury BK, Sahu S. Platform switching technique and crestal bone loss around dental implants: A systematic review. Ann Afr Med. 2019;18(1):01-06.
[29] Jensen-Louwerse C, Sikma H, Cune MS, Guljé FL, Meijer HJ. Single implant-supported two-unit cantilever fixed partial dentures in the posterior region: A retrospective case series with a mean follow-up of 6.5 years. Int J Implant Dent. 2021;7(1):01-07.
[30] Van Nimwegen WG, Raghoebar GM, Tymstra N, Vissink A, Meijer HJ. How to treat two adjacent missing teeth with dental implants: A systematic review on single implant-supported two-unit cantilever FDPs and results of a 5-year prospective comparative study in the aesthetic zone. J Oral Rehabil. 2017;44(6):461-71.
[31] Boemicke W, Gabbert O, Koob A, Krisam J, Rammelsberg P. Comparison of immediately loaded flapless-placed one-piece implants and flapped-placed conventionally loaded two-piece implants, both fitted with all-ceramic single crowns, in the posterior mandible: 3-year results from a randomised controlled pilot trial. Eur J Oral Implantol. 2017;10(2):179-95.
[32] de Oliveira Limírio JP, Lemos CA, de Luna Gomes JM, Minatel L, Rezende MC, Pellizzer EP. A clinical comparison of one-piece versus two-piece implants: A systematic review and meta-analysis. J Prosthet Dent. 2020;124(4):439-45.

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