Evaluation of Implant Survival by Analysing Dental Panoramic Radiographs: 10-Year Retrospective Study

Kader Cesur Aydin1, Selin Gaş2
1 Department of Dentomaxillofacial Radiology, 
Faculty of Dentistry, Istanbul Medipol 
University, Istanbul, Turkey 
2 Department of Oral and Maxillofacial Surgery, 
Faculty of Dentistry, Beykent University, 
Istanbul, Turkey

SUMMARY

Background/Aim: Panoramic radiographs have been used widely for pre-implant evaluation and the preparation of treatment protocols. Panoramic radiography is often the first choice method for the implant placements because it gives information on the overall shape of the jaws, the position of the maxillary sinus floor and the nasal cavity floor, and vertical position of the mandibular canal and the mental foramen in relation to dental implants. The specific aim of the present study was to evaluate 10-year survival rate of dental implants by analysis of dental panoramic radiographs. Material and Methods: This retrospective study was conducted on 507 panoramic radiographs of 156 implant patients. Initial oral health status, proceedings of Restorative/Endodontic treatments before implant placement, missing number of teeth and edentulism types, finalization of implant related prosthetic treatments during controls, implant quality scorings at baseline/controls and implant fails were analyzed. Results: The study results reveal statistically significant difference between the performed R/E treatment rates, according to the need for R/E treatments (p= 0.008). During the initial radiograph 96.1% of the implants were successful and 3.9% had satisfactory survival. At last control 86% of the implants were successful, 10.3% had satisfactory survival, 1% had impairment in survival and 2.8% were unsuccessful. The change in the last control compared to the initial radiograph is statistically significant (p= 0.000) regarding satisfactory survival. Conclusion: Long-term implant survival is not significantly affected by gender, age, type of edentulism, the presence of periodontal disease, R/E treatment needs, implant location, prosthesis type, and the presence of multiple implants.

Key words: Dental Implants, Survival, Dental Radiography, Oral Health

INTRODUCTION

The interpretation of the clinical outcomes of dental implant treatments is important in order to make a comparison between different implant treatment modalities and to benefit from the experience of the other physicians.

Since the first usage of dental implants, numerous clinical studies have been published and researchers have proposed several criteria to determine implant success. Parameters evaluating the quality of osseointegration such as implant bone support, implant mobility, inflammation or infection and bone loss around the implant were evaluated independent of mechanical and prosthetic factors1-4. While implant survival rates and success of dental implants before loading are quite high, only 2-3% of early implant losses are reported to be followed by fixed prosthetic restorations and 5% loss after loading overdenture prosthesis, within the initial 5 years5. Five year survival of single crown restorations were 96.5%, implant-implant supported fixed prosthetic restorations and implant-assisted restorations showed a survival rate of 90.1%6-8. As well as the differences in the definitions of success, failure and survival in clinical studies related to implants, there are also differences in terms of clinicians’
experience and skills, patient selection criteria, type and design of the study, and presentation and interpretation of data; that may vary according to countries and implant systems. Therefore, different results may be obtained from two clinical studies evaluating the same data. Although the terms success and survival in dental implants are often used without any distinction, these two criteria have different definitions in the dental literature. Survival describes the implants remaining in the mouth without technical and biological complications. The term ‘implant success’ is used to describe ideal clinical conditions and should cover a period of at least 12 months for implants. The term ‘early implant success’, has been proposed to be used for 1-3 years, ‘moderate implant success’, 3-7 years and ‘long term implant success’ for more than 7 years as well as including prosthetic survival rates.

Panoramic and periapical radiographs are common methods in initial dental implant planning. Panoramic radiography is an important imaging method to evaluate vertical bone height and detect oral health condition related to dental caries and periodontal diseases. Because of easy access, cheapness and informative features regarding jaw morphology panoramic radiography is one of the most common imaging methods for routine examination in clinical practice. However, due to the cost of medical investment, access to CBCT is limited, and it would be a clinical requisite to determine the magnification rate of panoramic radiographs to obtain correct diagnosis. Well-known procedural disadvantages of the panoramic radiography are poor definition, inconsistent magnification, geometric distortion and restricted measurement capability, as well as susceptibility for patients malposition. On the other hand, clinicians are tempted to measure distances and take the results as true values. Panoramic radiographs may benefit for implant within the panoramic image and take the results as true other hand, clinicians are tempted to measure distances and take the results as true values. However, due to the cost of medical investment, access to CBCT is limited, and it would be a clinical requisite to determine the magnification rate of panoramic radiographs to obtain correct diagnosis. Well-known procedural disadvantages of the panoramic radiography are poor definition, inconsistent magnification, geometric distortion and restricted measurement capability, as well as susceptibility for patients malposition. The primary purpose of the present retrospective clinical study was to determine the survival rate of dental implants with different trademarks, age, sex, implantation site, the presence of periodontal disease, restorative, endodontic, prosthetic treatment need and preferred prosthetic treatment option in systemically healthy patients radiologically.

Material and Methods

The study is planned as a retrospective study conducted on preoperative, intraoperative (initial) and control panoramic radiographs of implant patients between 2011-2020. Ethical Approval was obtained from Istanbul Medipol University Non-Interventional Clinical Researches Ethical Committee number 512. The research was conducted on 156 cases and 507 radiographs.

We evaluated initial oral health status (periodontal status, restorative/ endodontic treatment needs and prosthetic needs), proceedings of R/E (Restorative/ Endodontic) treatments before implant placement, missing number of teeth and edentulism types (single, multiple, free-end and total), finalization of implant related prosthetic treatments during controls, implant quality scorings at baseline/ controls and implant fails.

Evaluation of initial oral health status determinants were based on several criteria; 1. Presence of periodontal bone loss on the preoperative panoramic radiograph, 2. Restorative/Endodontic (R/E) treatment needs based on the preoperative panoramic radiograph, 3. Need for prosthetic treatments excluding the implants based on the preoperative panoramic radiograph.

The proceedings of R/E treatments were evaluated from 2 panoramic radiographs (preoperative and intraoperative) and evaluated as follows; 1. Treatments completed for all teeth, 2. No treatments completed, 3. Treatment was performed partially in the area adjacent to missing tooth.

The total number of missing teeth in each case was detected and classified as; single, multiple, free-ended and total edentulism and possible co-occurrences. The distribution of missing teeth classifications was evaluated. Distribution of planned implant types were classified as fixed/ removable prosthesis. Finalization of implant related prosthetic treatments during controls were evaluated via detection of fixed prosthesis and ball/ bar attachments for partial prostheses on the control panoramic radiographs.

Implant survival scorings based on alveolar bone level of implants were scored to determine vitality at baseline (intraoperative) and controls. The scorings were as follows: 1. Success: bone loss < 2 mm; 2. Satisfactory survival: 2-4 mm of radiographical bone loss; 3. Impairment in survival: > 4 mm or less than ½ of bone loss in radiography; 4. Unsuccessful (Fail): more than ½ length of bone loss in radiography. Regarding the vitality scorings, failed implants (score 4) was seperately evaluated for lifespan distribution and gender association.

IBM Statistical Package for Social Sciences (SPSS) version 22 (IBM Corp., Armonk, NY, USA) software program was used. For the evaluation of study data; descriptive statistical methods (mean, standard deviation, frequency) as well as Fisher’s Exact Chi-Square test, Fisher Freeman Halton Test, and Yates’s correction for continuity was used. Wilcoxon Sign test was used to evaluate the last control compared to the initial control. Significance was evaluated at p <0.05.

Results

The study was performed on 507 implants of 156 patients; 84 (53.8%) females and 72 (46.2%) males. The number of placed implants ranged from 1-13/ case (mean 3.25±2.62 and median 2). The number of missing teeth ranged from 1-28/ case (mean 8.47±7.80 and median 6).
(R/E) treatment, 7 cases need prosthetic treatment and 70 had existing prosthesis. Prior to implant placement; preoperative panoramic radiographs were checked in all patients; R/E treatment was performed for all teeth in 7.1% of patients, treatment was performed partially in the area adjacent to missing in 5.2% and R/E treatment was not performed in 87.7% of patients.

After implant treatment has started, tooth extraction requirement was seen in 16% of patients. The reasons for tooth extractions were related with lack of R/E treatment, periodontal disease and combination of periodontal disease and lack of R/E treatment; 64%, 28% and 8% respectively.

Evaluation of causes of tooth extractions after starting implant treatment in the relation to periodontal disease, need for R/E treatment vs. R/E treatment status are presented in Table 2. In cases with tooth extraction after starting implant treatment; regarding the presence of periodontal disease, there was no statistically significant difference between the rates of R/E treatment status (p> 0.05). On the contrary as a great cause for delayed tooth extraction need, R/E treatment was performed partially in the area adjacent to missing teeth in 16.7% and was not performed in 83.3% of patients that need R/E treatment. There is statistically significant difference between the performed R/E treatment rates, according to the need for R/E treatments (p= 0.008). R/E treatment was performed in 26.7% and was not performed in 73.3% of those who do not need R/E treatment.

### Table 1. Distribution of oral health information in all implant cases before implant treatment

| Patient (n) | Implant (n) | %  |
|-------------|-------------|----|
| Periodontal Disease | 60          | 138 | 38.5 |
| No Periodontal Disease | 96          | 171 | 61.5 |
| Need for R/E treatment | 52          | 109 | 33.3 |
| No need for R/E treatment | 104         | 200 | 66.7 |
| Need for prosthetic treatment | 7           | 17  | 4.5  |
| No need for prosthetic treatment | 79         | 146 | 50.6 |
| Existing prosthesis | 70          | 146 | 44.9 |
| R/E treatments completed | 11          | 28  | 7    |
| R/E treatments is not completed | 136        | 259 | 87.2 |
| R/E treatments partially completed in the area adjacent to missing teeth | 8           | 21  | 5.1  |
| R/E treatments completed in the area adjacent to missing teeth | 1           | 1   | 0.7  |

Distribution of oral health information of all cases regarding periodontal status, planned and completed R/E treatments and prosthetic treatment needs excluding the implants are presented in Table 1. 60 cases have periodontal disease, 52 cases need restorative/endodontic treatment, 7 cases need prosthetic treatment and 70 had existing prosthesis. Prior to implant placement; preoperative panoramic radiographs were checked in all patients; R/E treatment was performed for all teeth in 7.1% of patients, treatment was performed partially in the area adjacent to missing in 5.2% and R/E treatment was not performed in 87.7% of patients.

Table 2. Evaluation of the causes of tooth extractions after starting implant treatment according to periodontal disease/need for R/E treatment status

| Tooth extraction (n= 44) | Status of R/E treatment before implant (n %) | P       |
|--------------------------|---------------------------------------------|---------|
|                          | All                          | None                        | Partial             |        |
| Periodontal disease      |                             |                             |                      | 1.058   |
| Yes                      | 6 (%21.4)                    | 19 (%67.9)                  | 3 (%10.7)            |        |
| No                       | 2 (%12.5)                    | 14 (%87.5)                  | 0 (%0)               |        |
| Need for R/E treatment   |                             |                             |                      | 0.008*  |
| No                       | 8 (%26.7)                    | 22 (%73.3)                  | 0 (%0)               |        |
| Adjacent to missing teeth| 0 (%0)                       | 1 (%50)                     | 1 (%50)              |        |

1Fisher-Freeman-Halton exact test  2Fisher’s Exact Test  *p< 0.05

Table 3. Distribution of edentulism types

| Edentulism types                     | n  | %  |
|--------------------------------------|----|----|
| Single + Multiple + Free-end         | 37 | 23.7 |
| Single                               | 37 | 23.7 |
| Multiple Free-end                    | 23 | 14.7 |
| Single + Multiple                    | 13 | 8.3 |
| Multiple Free-end + Total            | 10 | 6.4 |
| Total                                | 13 | 8.3 |
| Multiple                             | 11 | 7.1 |
| Single Free-end                      | 5  | 3.2 |
| Multiple + Total                     | 5  | 3.2 |
| Single + Multiple + Total            | 2  | 1.3 |

Classification of edentulism was determined as single, multiple, free- end, total edentulism and possible combinations. The most common occurrence was 23.7% of Single+ Multiple+ Free-end edentulism combination as well as single implants. General distribution of edentulism types in the study group are displayed in Table 3.

Results for survival based implant scorings at initial and last controls are displayed in Table 4. During the initial radiograph 96.1% of the implants were successful and 3.9% had satisfactory survival. Last control radiographs revealed that 86% of the implants were successful, 10.3% had satisfactory survival, 1% had impairment in survival and 2.8% were unsuccessful. Regarding last control radiographs’ time, 41.4 % had only the initial radiograph, 30% had up to 1 year control,
16.6% had 1-5 years control period and 12% had 6-10 years control. The change in the last control compared to the initial radiograph is statistically significant (p= 0.000) regarding satisfactory survival. While scorings about impairment in survival and unsuccessful ratings are low, no statistical significance is found for implant failure.

Implant survival scorings based on prognosis and bone loss were performed on 507 implants of a total of 156 patients; 84 (53.8%) females and 72 (46.2%) males. A total of 14 (2.8%) implants were lost. Regarding gender, implant losses were 3.1% in females, and 2.4% in males. Yates’s correction for continuity tests proved there is no statistically significant difference between genders (p= 0.862). Fail time of implants were determined and 21.4% of implant losses were at 3 months, 28.6% at 6 months, 7.1% at 48 months, 7.1% at 60 months, 7.1% at 72 months, 21.4% at 84 months and 7.1% were seen at 132 months. Regarding the relation of periodontitis and implant fail, 78.6% of failed implants had periodontal disease background due to the preop panoramic evaluation. 14% of the failed implants were related to periodontal disease and 28% were related to unfinished R/E treatments regarding increasing tooth loss after placement of the implants.

The planned prosthesis type in all cases were 88.5% fixed and 11.5% removable prosthesis and during controls 32% of all prosthesis were completed.

### Table 4. Implant survival scorings based on intraoperative versus last controls.

| Last control          | Intraoperative control | Satisfactory survival | Total | p          |
|-----------------------|------------------------|-----------------------|-------|------------|
| Success               | 435 (%89.3)            | 1 (%5)                | 436 (%86) |            |
| Satisfactory survival | 39 (%8)                | 13 (%65)              | 52 (%10.3) | 0.000*     |
| Impairment in survival| 3 (%0.6)               | 2 (%10)               | 5 (%4)   |            |
| Unsuccessful (Fail)   | 10 (%2.1)              | 4 (%20)               | 14 (%2.8) |            |
| Total                 | 487 (%96.1)            | 20 (%3.9)             | 507 (%100) |            |

Wilcoxon sign test * p< 0.05

### Discussion

Longitudinal studies evaluating dental implants usually display satisfactory results12, 18-20. While some studies relate to ‘survival’, some refer the term ‘success’ for the determination of implant vitality18. Among many implant survival criteria, modified version involving the radiological classification of the ICOI Consensus results for Implant success, survival, and failure be Misch et al. is used in the study, and scorings were adapted to perform radiological survival12. Like proved in several systematic reviews, the survival rates were as high as 96.1% at the initial and 86% at the last controls of our study19-20.

Survival rates of implants in periodontally healthy subjects are higher than periodontally compromised individuals21. In the current study group, we have detected 2.8% implant loss. Although no gender predisposition have been detected (p= 0.862), 78.6% of the failed implants had periodontal disease background and 14% had both periodontal disease and periodontal related to tooth loss after implant placement. As well as implant failures, 16% of all cases of the study group displayed need for tooth extractions after placement of dental implants, 36% were related to periodontal problem issues. The high percentage of periodontal disease versus implant loss ratio is found to be negatively related in the study. On the contrary, 83.3% of patients that need R/E treatment were not treated before implant placement, and 2/3 of all tooth extractions after placement of dental implants were related to R/E treatment needs. From this data we can conclude that, R/E treatment needs cause twice more risk than periodontal diseases in dental implant planned patients, with regard to tooth loss potential.

The study group analytics revealed that ¼ of all placed implants were for single, and also ¼ were for a combination of single+ multiple+ free ended edentulism types. 10.9% of all cases had at least single jaw total edentulism, and 8.3% were bimaxillary total edentulism. Although, wider and multicenter studies may reveal different results due to sociodemographic effects and locations. Regarding the relation of edentulism types and planned prosthesis type; 88.5% fixed and 11.5% removable prosthesis were planned. This data reveals that single jaw total edentulism/ partially dentate jaw combinations are mainly planned to support fixed prostheses. A review of the literature by Gallucci et al. supports that with careful communication and follow-ups, total edentulism can be successfully treated with fixed prosthetic approaches22. Balshi et al. also remarks that degree of edentulism and prosthesis type does not effect implant survival23.

The magnification and distortion effects of the panoramic procedures lead to inconsistency with realtime measurements16-17. Therefore, instead of directly measuring the length of bone loss to determine survival, a
4 grade survival scoring system adapted from Misch et al. is used to evaluate bone loss in panoramic radiographs.

Depending on the current study, it can be concluded that edentulism and prosthesis types does not effect implant prognosis, when handled and managed with knowledge. In radiological evaluation of long-term implant success in the future, it is necessary to establish standards in order to make a scientifically valid comparison between different technologies and applications.

Patient gender, age, type of edentulism, the presence of periodontal disease, R/E treatment needs, implant location, prosthesis type, and the presence of multiple implants did not result in any significant effect on long-term implant survival.

Conclusion

Long-term implant survival is not significantly affected by gender, age, type of edentulism, the presence of periodontal disease, R/E treatment needs, implant location, prosthesis type, and the presence of multiple implants.

References

1. Nazeer J, Singh R, Suri P, Mouneshkumar CD, Bhardwaj S, Iqubal MA et al. Evaluation of marginal bone loss around dental implants in cigarette smokers and nonsmokers. A comparative study. J Family Med Prim Care, 2020;9:729-734.
2. Tercanli Alkis H, Turker N. Retrospective evaluation of marginal bone loss around implants in a mandibular locator-retained denture using panoramic radiographic images and finite element analysis: A pilot study. Clin Implant Dent Relat Res, 2019;21:1199-1205.
3. Albrektsson T, Jansson T, Lekholm U. Osseointegrated dental implants. Dent Clin North Am, 1986;30:151-174.
4. Balshi TJ, Wolfinger GJ, Stein BE, Balshi SF. A long-term retrospective analysis of survival rates of implants in the mandible. Int J Oral Maxillofac Implants, 2015;30:1348-1354.
5. Barrachina-Diez JM, Tashkandi E, Stampf S, Att W. Long-term outcome of one-piece implants. Part I: implant characteristics and loading protocols. A systematic literature review with meta-analysis. Int J Oral Maxillofac Implants, 2013;28:503-518.
6. Brägger U, Karouissi I, Persson R, Pjetursson B, Salvi G, Lang N. Technical and biological complications/failures with single crowns and fixed partial dentures on implants: a 10-year prospective cohort study. Clin Oral Implants Res, 2005;16:326-334.
7. Howe MS, Keys W, Richards D. Long-term (10-year) dental implant survival: A systematic review and sensitivity meta-analysis. J Dent, 2019; 84:9-21.
8. 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 multi-center study with 2359 implants. Clin Oral Implants Res, 1997;8:161-172.
9. Choi JW. Assessment of panoramic radiography as a national oral examination tool: review of the literature. Imaging Sci Dent, 2011;41:1-6.
10. Douglass CW, Valachovic RW, Wijesinha A, Chauncey HH, Kapur KK, McNeil BJ. Clinical efficacy of dental radiography in the detection of dental caries and periodontal diseases. Oral Surg Oral Med Oral Pathol, 1986;62:330-339.
11. Gallucci GO, Avrampou M, Taylor JC, Elpers J, Thalji G, Cooper LF. Maxillary Implant-Supported Fixed Prosthesis: A Survey of Reviews and Key Variables for Treatment Planning. Int J Oral Maxillofac Implants, 2016;31:192-197.
12. Holm-Pedersen P, Lang NP, Müller F. What are the longevities of teeth and oral implants? Clin Oral Implants Res, 2007;18:15-19.
13. Jemt T, Lekholm U, Adell R. Osseointegrated implants in the treatment of partially edentulous patients: a preliminary study on 876 consecutively placed fixtures. Int J Oral Maxillofac Implants, 1989;4:211-217.
14. Jung RE, Pjetursson BE, Glauer R, Zembic A, Zwahlen M, Lang NP. A systematic review of the 5-year survival and complication rates of implant-supported single crowns. Clin Oral Implants Res, 2008;19:119-130.
15. Kim YK, Park JY, Kim SG, Kim JS, Kim JD. Magnification rate of digital panoramic radiographs and its effectiveness for preoperative assessment of dental implants. Dentomaxillofac Radiol, 2011;40:76-83.
16. Lang NP, Pjetursson BE, Tan K, Lang NP, Bragger U, Egger M et al. A systematic review of the survival and complication rates of fixed partial dentures (FPDs) after an observation period of at least 5 years. II. Combined tooth–implant-supported FPDs. Clin Oral Implants Res, 2004;15:643-653.
17. Misch CE, Perel ML, Wang HL, Sammartino G, Galindo-Moreno P, Trisi P et al. Implant success, survival, and failure: the International Congress of Oral Implantologists (ICOI) Pisa Consensus Conference. Implant Dent. 2008;17:5-15.
18. Moraschini V, Poubel LA, Ferreira VF, Barboza Edos S. Evaluation of survival and success rates of dental implants reported in longitudinal studies with a follow-up period of at least 10 years: a systematic review. Int J Oral Maxillofac Surg, 2015;44:377-388.
19. Morris HFM, Ochi S. Clinical studies of endosseous dental implants: The good, the bad and the ugly. Ann Periodontol, 2000;5:6-11.
20. Simonis P, Dufour T, Tenenbaum H. Long-term implant survival and success: A 10-16-year follow-up of non-submerged dental implants. Clin Oral Implants Res, 2010;21:772-777.
21. Smith DE, Zarb GA. Criteria for success of osseointegrated endosseous implants. J Prosthet Dent, 1989;62:567-572.
22. Sousa V, Mardas N, Farias B, Petrie A, Needleman I, Spratt D et al. A systematic review of implant outcomes in treated periodontitis patients. Clin Oral Implants Res, 2016;27:787-844.
Conflict of Interests: Nothing to declare.
Financial Disclosure Statement: Nothing to declare.
Human Rights Statement: All the procedures on humans were conducted in accordance with the Helsinki Declaration of 1975, as revised 2000. Consent was obtained from the patient/s and approved for the current study by national ethical committee.
Animal Rights Statement: None required.