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Clinical outcomes of dental implants placed in fresh sockets: A five-year retrospective study

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ABSTRACT

Purpose: This retrospective clinical study aimed to evaluate the implants placed in fresh sockets and investigate the effect of varied oral health conditions and treatment plan details on the clinical and radiographic outcomes.
Materials and methods: Fifty-nine participants (102 implants) were included in this study. Four variables, including mean probing depth (PD), mean marginal bone loss (MBL), pink esthetic score (PES), and patient satisfaction, were significant dependent variables, and the effects of independent variables on these four items were studied. The data were analyzed by the analysis of covariance (ANCOVA) using a statistical software.
Results: The mean follow-up period was 4.75 ± 1.74 years, and the mean MBL was 1.21 ± 0.81 mm. The survival rate was 97 %. There were significant effects of the finish line site, keratinized gingival width, and attached gingival width on PD after adjusting the factors. Also, the implant brand, plaque index, and uncemented prosthesis affected MBL significantly. In addition, significant effects of the surgeon, implant brand, and proximal contact on PES were found.
Conclusion: More PD was found around restorations with a finish line site > 1.5 mm subgingival. Sufficient attached gingiva was a more effective factor on PD than keratinized gingiva. Implants with more plaque scores showed more MBL.

1. Introduction

Immediate dental implant placement after tooth extraction is commonly referred to as a "fresh socket" procedure. This approach offers several advantages, including a shorter edentulous period, reduced patient morbidity due to single-visit surgeries, decreased post-extraction bone resorption, and preservation of soft tissue (Esposito et al., 2010; Lin et al., 2014; Morton et al., 2004; Oxby et al., 2015; Slagter et al., 2014). Implants with various geometries, when placed immediately in extraction sockets, are associated with proper healing of both hard and soft tissues (Sanz et al., 2014). Moreover, the positive impact of restoration placement on short-term esthetic outcomes and soft tissue form and volume has been substantiated (Barone et al., 2016; Belser et al., 2009).

However, the fresh socket method presents certain challenges, such as dealing with different implant and root shapes, which can make achieving primary stability difficult. Additionally, inadequate keratinized tissue for flap closure poses another challenge. Successful fresh socket implant placement requires a skilled surgeon and careful patient selection (De Rouck et al., 2008).

Primary stability is crucial for successful implant placement, whether in healed bone or fresh sockets (Andersson et al., 2019). Achieving sufficient primary stability necessitates atraumatic tooth extraction to preserve bone. The osseo-densification drilling technique has also been shown to enhance *peri*-implant bone quality (Inchingolo et al., 2021).

Determining the need for a socket preservation procedure should be based on desired aesthetic and functional outcomes (Juodzbalys et al., 2019). Factors such as available bone quality and quantity and gingival biotype should be considered. Some studies have reported improved bone formation in grafted sockets using bone substitutes compared to untreated sockets (Adel-Khattab et al., 2020; Ramanauskaite et al., 2019). A *meta*-analysis even found a 95–100 % survival rate for implants placed in grafted sockets (Ramanauskaite et al., 2019).

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Previous studies have deemed marginal bone loss (MBL) of less than 0.1 mm/year as acceptable (Meijer et al., 2018). Contemporary approaches aim to maintain zero bone loss (Linkevicius et al., 2009). The etiology of *peri*-implant MBL encompasses both biomechanical and biological factors (Ebadian et al., 2020). In fresh socket implant placement, MBL is influenced by factors such as implant location, bone substitute type, and membrane application (Chang et al., 2015).

The significance of adequate keratinized tissue around implants and healthy gingival conditions for marginal bone stability has been confirmed (Berglundh et al., 2018; Chang et al., 2015). The presence of sufficient *peri*-implant keratinized mucosa and $>$ 2 mm of gingival thickness at the crest has been validated (Boynueğri et al., 2013; Linkevicius et al., 2009). Peri-implantitis, characterized by plaque-related inflammation of *peri*-implant mucosa, can lead to MBL (Ahn et al., 2019; Berglundh et al., 2018). A history of periodontal disease increases the risk of implant failure (Busenlechner et al., 2014). Thus, periodontal therapy is more effective before implant placement to enhance gingival health (Chang et al., 2015).

Studies exploring factors like oral hygiene, prosthesis type, and edentulous region have reported varied results regarding implant survival rates, probing depth, and MBL (Lin et al., 2014; Nemli et al., 2016). Comprehensive clinical parameter assessment is recommended for successful fresh socket implant placements (Barone et al., 2016; Juodzbalys et al., 2019; Ramanauskaite et al., 2019). While one study suggested a higher risk of implant failure with the fresh socket method (Esposito et al., 2010), others have reported comparable outcomes between implants placed in fresh sockets and those placed in pristine bone (early healing). These two groups exhibited similar short-term survival rates and clinical outcomes (Chen et al., 2004; Guarnieri et al., 2020).

In the context of implant therapy, various factors should be investigated to achieve optimal outcomes for both hard and soft tissues (Slagter et al., 2014). Few studies have evaluated the impact of prosthetic characteristics on these outcomes (Guarnieri et al., 2014; Sanz et al., 2014). Therefore, it is crucial to investigate esthetic outcomes, including gingival tissue shape and condition, and factors influencing soft tissues. Additionally, systematic reviews have emphasized the need for long-term follow-up studies to assess dental implants placed in fresh sockets (Chen et al., 2004).

This study aims to evaluate implants placed in fresh sockets and investigate the influence of oral health conditions, treatment plan details, implant and prosthesis characteristics, and surgical approach factors on clinical and radiographic outcomes. The null hypothesis posits that these factors do not affect probing depth, marginal bone loss, pink esthetic score, and patient satisfaction.

2. Materials and methods

This clinical retrospective study investigated the population that received dental implants in fresh extraction sockets. The participants had been treated at Dental Implants Research Center in Isfahan between Jan 2011 and July 2018. Total population sampling was carried out to enroll the participants who received final restorations at a minimum of one year before. The same surgical and prosthesis fabrication protocol had been followed for all the participants by a special team of surgeons and prosthodontists (Oxby et al., 2015).

2.1. Participants selection

Participants meeting the inclusion criteria and providing written informed consent were enrolled in the study. Individuals were excluded from participation if they had any of the following conditions: uncontrolled systemic disease, a history of chemotherapy or radiotherapy, current use of bisphosphonates or corticosteroid drugs, or were pregnant. Ethical approval for the study protocol was granted by the Isfahan Regional Bioethics Committee (IR.MUI.RESEARCH.REC.1399.389). This study was conducted in strict accordance with the principles outlined in the World Medical Association Declaration of Helsinki.

2.2. Examination and data collection

All the participants were examined and evaluated by an operator. A radiologist provided photostimulable phosphor (PSP) plate-based parallel bite-wing radiographs (Dental AG, Bietigheim-Bissingen, Germany) for all the participants. The examiner and radiologist were blinded to the surgeon and prosthodontist.

2.2.1. Checklist

The following data were systematically collected for each participant, utilizing a comprehensive checklist: Age, sex, education, prosthesis age (follow-up period), implant brand and implant width/length, implant type (bone level/tissue level), surgeon (professor/resident), replaced tooth type (anterior/posterior), presence or absence (P/A) of guided bone regeneration (GBR), prosthesis type (crown/bridge), finish line location (supragingival/at gingival level/up to 1.5 mm subgingival/over 1.5 mm subgingival), P/A history of returning to the clinic, P/A history of uncemented prosthesis, opposite dentition (tooth/implant), occlusal contacts of restoration in maximum intercuspation (MIC) (no/functional/heavy) and during excursive movements (P/A), quality of proximal contact (loose/normal or splinted), keratinized and attached gingival width (mm) (Loe, 1967), gingival biotype (thick/thin), P/A of bleeding on probing, plaque and gingival indices (0–3 scores) (Loe, 1967), mean probing depth (PD), mean marginal bone loss (MBL), pink esthetic score (PES), and patient satisfaction (100-mm visual analogue scale).

2.2.2. Probing depth and marginal bone loss

For PD measurements, four specific points were assessed: mesiobuccal, midbuccal, distobuccal, and midlingual. Probing was conducted using a millimeter-graded color-coded periodontal probe (PCP 15, Hu-Friedy, Chicago, Ill) until discomfort was felt (0.24 N). Subsequently, MBL was measured as the mean distance from the crestal bone level to the implant's crest module on both the mesial and distal sides. These measurements were accurately recorded using a digital ruler integrated into the PSP software (Calvo-Guirado et al., 2018; Ebadian et al., 2020).

2.2.3. Pink esthetic score

Peri-implant gingival tissues were evaluated by measuring PES using the following five parameters: mesial papilla, distal papilla, the curvature of emergence line of the restoration, vertical level of free gingiva, and a combination of three facial side variables of root convexity, gingival color, and texture. Each parameter for implants was compared to natural teeth and then was scored from 0 to 2. The "0", "1", and "2" scores were allocated to major, minor, and no discrepancy, respectively. Finally, the scores were added up, and the sum of PES was calculated for each implant, in which the optimum conditions were scored 10 (Slagter et al., 2014).

2.3. Statistical analysis

In this study, four variables, including mean PD, mean MBL, PES, and patient satisfaction, were significant dependent variables, and the effect of independent variables on these four items was studied. In this order, independent variables with two groups using independent *t*-test and variables with more than two groups using analysis of variance were compared for values of each dependent variable. Finally, independent variables with P-values ≤ 0.3 were included in the analysis of covariance (ANCOVA) model of each dependent variable. ANCOVA consists of both analysis of variance and general linear regression and can manage the effect of confounding factors. The data were analyzed using a statistical software program (IBM SPSS Statistics, v24; IBM Corp) by a statistician blinded to the data ($a = 0.05$ for all tests).

3. Results

In this study, 102 implants were investigated. Three implants had failed (97 % survival rate). The descriptive characteristics of 99 implants (59 participants) are presented in Table 1. The mean follow-up period was 4.75 ± 1.74 years, and the mean MBL was 1.21 ± 0.81 mm.

3.1. Probing depth

The results of ANCOVA for comparing PD between independent variables are presented in Table 2. The finish line site, keratinized gingival width, and attached gingival width significantly affected PD after adjusting the factors. A significantly deeper PD was found in restorations with finish line site > 1.5 mm supragingival compared with supragingival finish lines. In the participants with deeper PD, larger keratinized gingival width and smaller attached gingival width were observed.

3.2. Marginal bone loss

The results of ANCOVA for comparing MBL between independent variables are presented in Table 3. The implant brand, plaque index, and uncemented prosthesis significantly affected MBL after adjusting the factors. In the "Dio" group (Dio Implant Co, Korea), significantly less MBL was found compared with the "Snucone" (Snucone Dental Implant, Korea) and "Others" groups. There was no other significant difference in MBL between other implant brands. The significant difference in pairwise comparison between plaque index scores was more MBL in the group with score "2" compared with scores "1" and "0."

3.3. Pink esthetic score

The results of ANCOVA for comparing PES between independent variables are presented in Table 4. The surgeon, implant brand, and proximal contact significantly affected PES after adjusting factors. In pairwise comparisons between the four groups of implant brands, the "Dio" group showed significantly higher PES compared with each of the three groups. Also, there were no other significant differences between the groups.

3.4. Patient satisfaction

The results of ANCOVA for comparing patient satisfaction between independent variables are presented in Table 5. The surgeon, need for returning to the clinic, and implant brand significantly affected patient satisfaction after adjusting the factors. The participants receiving implants by professors as the surgeon, with no history of the need for returning to the clinic, and treated using "Dio" implants reported more satisfaction.

Table 1
Description of the studied population.

Variables	Description	
Age	Mean ± SD: 50.9 ± 13.17, min: 22, max: 89	
Sex	34 males (53 implants) and 25 females (46 implants)	
Education	31 non-academic (59 implants) and 28 academic (40 implants)	
Prosthesis age (year)	Mean ± SD: 4.75 ± 1.74, min: 1, max: 8	
Implant brand	Brand	Frequency (Percent)
	Zimmer (Dental Inc, USA)	13 (13.1)
	Dio	23 (23.2)
	Snucone	40 (40.5)
	Others	23 (23.2)
	Sum	99 (100)
Implant type	81 bone level and 18 tissue level	
Tooth type	54 anterior teeth and 45 posterior teeth	
Prosthesis type	42 crowns and 57 bridges	
Guided bone regeneration	36 no and 63 yes	
Mean probing depth	Mean ± SD: 2.27 ± 0.71, min: 1, max: 4.5	
Mean marginal bone loss	Mean ± SD: 1.21 ± 0.81, min: 0, max: 3.8	
Pink esthetic score	Mean ± SD: 4.99 ± 2.22, min: 0, max: 9	
Patient satisfaction	Mean ± SD: 82.42 ± 19.27, min: 20, max: 100	

Table 2
Results of ANCOVA for comparing mean probing depths.

Independent variables	B	t	P-value
Age	0.005	1.104	0.273
Prosthesis age (Year)	−0.009	−0.303	0.763
Implant brand (Zimmer)	−0.174	−0.959	0.34
Implant brand (Dio)	−0.18	−1.249	0.216
Implant brand (Snucone)	−0.191	−1.471	0.145
Implant brand (Others)	0		
Implant type (bone level)	0.055	0.359	0.72
Implant type (tissue level)	0		
Bleeding on probing (no)	−0.251	−0.778	0.439
Bleeding on probing (yes)	0		
Gingival index (0)	0.336	0.867	0.388
Gingival index (1)	0.218	0.671	0.504
Gingival index (2)	0		
Gingival type (thick)	−0.148	−0.623	0.535
Gingival type (thin)	0		
Prosthesis type (crown)	0.053	0.337	0.737
Prosthesis type (bridge)	0		
Opposite dentition (tooth)	−0.06	−0.477	0.635
Opposite dentition (implant)	0		
Proximal contact (loose)	−0.167	−1.453	0.15
Proximal contact (normal or splinted)	0		
Finish line site (supragingival)	−0.5	−2.602	**0.011**
Finish line site (at gingival)	−0.233	−1.287	0.202
Finish line site (≤1.5 mm subgingival)	−0.239	−1.666	0.10
Finish line site (>1.5 mm subgingival)	0		
Guided bone regeneration (no)	−0.81	−0.691	0.492
Guided bone regeneration (yes)	0		
Keratinized gingival width	0.609	8.224	**<0.001**
Attached gingival width	−0.601	−7.907	**<0.001**

Table 3
Results of ANCOVA for comparing the mean marginal bone loss.

Independent Variables	B	t	P-value
Annual recall (no)	0.032	0.201	0.841
Annual recall (yes)	0		
Implant brand (Zimmer)	−0.033	−0.109	0.914
Implant brand (Dio)	−0.655	−2.739	**0.008**
Implant brand (Snucone)	0.051	0.238	0.812
Implant brand (Others)	0		
Implant type (bone level)	0.175	0.734	0.465
Implant type (tissue level)	0		
Plaque index (0)	−0.725	−2.637	**0.01**
Plaque index (1)	−0.614	−2.24	**0.028**
Plaque index (2)	0		
Uncemented prosthesis (no)	0.475	2.43	**0.017**
Uncemented prosthesis (yes)	0		
Finish line site (supra gingival)	0.224	0.825	0.412
Finish line site (at gingival)	−0.160	−0.593	0.555
Finish line site (≤1.5 mm infra gingival)	−0.189	−0.851	0.397
Finish line site (>1.5 mm infra gingival)	0		
Implant length	0.132	1.868	0.065
Keratinized gingival width	−0.019	−0.439	0.662

4. Discussion

The null hypothesis that oral health and host condition, implant and prosthesis characteristics, and surgical approach factors do not influence probing depth, marginal bone loss, pink esthetic score, and patient satisfaction was rejected. The surgeon factor influenced both satisfaction and PES. Also, the role of oral health and host conditions in MBL and PD was significant.

Our findings align with a study that reported 1.4 mm of marginal bone loss (MBL) and acceptable *peri*-implant soft tissue conditions for

Table 4
Results of analysis of covariance for comparing sum of pink score.

Independent Variables	B	t	P-value
Age	−0.010	−0.472	0.638
Education (non-academic)	−0.477	−0.96	0.34
Education (academic)	0		
Surgeon (professor)	−1.469	−3.036	**0.003**
Surgeon (resident)	0		
Annual recall (no)	0.321	0.638	0.525
Annual recall (yes)	0		
Implant brand (Zimmer)	0.301	0.396	0.693
Implant brand (Dio)	1.939	2.997	**0.004**
Implant brand (Snucone)	0.353	0.529	0.598
Implant brand (Others)	0		
Bleeding on probing (no)	0.535	0.36	0.72
Bleeding on probing (yes)	0		
Gingival index (0)	−2.308	−1.341	0.184
Gingival index (1)	−0.077	−0.049	0.961
Gingival index (2)	0		
Plaque index (0)	0.65	0.683	0.497
Plaque index (1)	0.573	0.77	0.443
Plaque index (2)	0		
Gingival type (thick)	−0.178	−0.147	0.883
Gingival type (thin)	0		
Prosthesis type (crown)	0.269	0.417	0.678
Prosthesis type (bridge)	0		
Occlusion in MIC (non-functional)	0.578	0.444	0.659
Occlusion in MIC (functional)	0.955	0.741	0.461
Occlusion in MIC (heavy contact)	0		
Occlusal contact in laterotrusive (no)	−0.86	−1.975	0.052
Occlusal contact in laterotrusive (yes)	0		
Opposite dentition (tooth)	0.515	0.764	0.448
Opposite dentition (implant)	0		
Proximal contact (loose)	1.195	2.324	**0.023**
Proximal contact (normal or splinted)	0		
Finish line site (supragingival)	0.669	0.855	0.395
Finish line site (at gingival)	1.1	1.482	0.143
Finish line site (≤1.5 mm subgingival)	0.57	0.946	0.347
Finish line site (>1.5 mm subgingival)	0		
Keratinized gingival width	−0.001	−0.008	0.993

Table 5
Results of ANCOVA for comparing patient satisfaction.

Independent Variables	B	t	P-value
Sex (female)	−2.084	−0.516	0.607
Sex (male)	0		
Surgeon (attendant)	11.907	2.894	**0.005**
Surgeon (resident)	0		
Need for returning to the clinic (no)	10.694	2.637	**0.01**
Need for returning to the clinic (yes)	0		
Implant brand (Zimmer)	−15.341	−2.428	**0.017**
Implant brand (Dio)	2.039	0.364	0.717
Implant brand (Snucone)	−18.431	−3.425	**0.001**
Implant brand (Others)	0		
Tooth (anterior)	7.179	1.766	0.081
Tooth (posterior)	0		
Gingival index (0)	3.806	0.479	0.633
Gingival index (1)	3.807	0.719	0.474
Gingival index (2)	0		
Plaque index (0)	2.739	0.344	0.732
Plaque index (1)	1.714	0.268	0.789
Plaque index (2)	0		
Gingival type (thick)	6.869	0.685	0.496
Gingival type (thin)	0		
Prosthesis type (crown)	5.527	1.19	0.237
Prosthesis type (bridge)	0		
Occlusion in MIC (non-functional)	3.262	0.294	0.77
Occlusion in MIC (functional)	2.168	0.198	0.844
Occlusion in MIC (heavy contact)	0		
Opposite dentition (tooth)	−8.185	−1.55	0.125
Opposite dentition (implant)	0		
Proximal contact (loose)	0.109	0.027	0.979
Proximal contact (normal or plinted)	0		

implants placed in fresh sockets over a five-year follow-up period (Esposito et al., 2010). Current criteria and research interests in implant therapy emphasize achieving optimal outcomes for both hard and soft tissues (Lin et al., 2014). In our study, while no implant received a perfect PES score of 10, participants expressed an 82 % satisfaction rate, indicating overall good condition. Furthermore, fresh socket implant placement for both anterior and posterior teeth yielded comparable results. The highest recorded probing depth (PD) was 4.5 mm, signifying acceptable gingival health (Morton et al., 2004).

The survival rate in the present study (97 %) is comparable to previous studies with similar follow-up periods (Barone et al., 2016; Belser et al., 2009; Sanz et al., 2014). The importance of considering total host factors and atraumatic implant insertion surgery for successful implant placement has been confirmed (De Rouck et al., 2008). Based on the findings of the present study, the participants who underwent implant surgery by professors reported significantly higher satisfaction rates compared with residents. However, implants placed by professors showed significantly lower PES. These findings refer to the effect of the dentist-patient relationship on patient satisfaction and present the role of considering all details to achieve the best soft tissue-related outcomes.

In the present study, the participants who did not need to return to the clinic reported more satisfaction than participants who needed to return. This finding showed the importance of patient education that implant therapy is no cure and is the only treatment needing regular recalls.

There were significant differences between the plaque index scores. An implant score of “2” compared with scores “1” and “0” showed more MBL. This finding confirmed the role of biological factors as an etiology for MBL (Andersson et al., 2019). Also, restorations with an uncemented history resulted in less MBL. This finding can also verify the role of oral health on MBL. Cleaning the gingival surface of restorations using dental floss in splinted restorations might increase the rate of the uncemented prosthesis.

The destructive role of bacterial plaque in gingival tissue has been well-established (Andersson et al., 2019). In this context, previous studies have highlighted the impact of the crown-abutment finish line in retaining plaque and its potential for biologic pumping (Inchingolo et al., 2021; Morton et al., 2004). Consequently, the optimal placement for the finish line is supragingival. Consistent with this premise, our study observed significantly greater probing depths (PD) in restorations where the finish line was located more than 1.5 mm subgingival, as compared to those with supragingival finish lines.

The importance of keratinized gingiva in providing healthy *peri*-implant tissue has been confirmed (Adel-Khattab et al., 2020; De Rouck et al., 2008; Juodzbalys et al., 2019). The participants with deeper PD had larger keratinized gingival width and smaller attached gingival width. In this order, another finding was the absence of the effect of gingival biotype on clinical outcomes. Based on these findings, providing sufficient *peri*-implant attached gingiva should be considered a more effective factor than keratinized gingiva.

A study discussed the role of restorations in improving *peri*-implant soft tissues (Ramanauskaite et al., 2019). The quality of occlusal contacts in MIC did not influence clinical outcomes. However, restorations with normal proximal contact showed weaker outcomes concerning *peri*-implant gingival conditions than loose proximal contacts. This finding might raise from our proximal contact quality classification. In this study, splinted restoration proximal contacts were assumed to be normal. Hence, the incomplete papilla and *peri*-implant mucositis, which are common beneath the splinted restorations (Morton et al., 2004), might have led to this result.

The implants with the “Dio” brand provided more satisfaction, less MBL, and larger PES. The better outcomes of the “Dio” brand for implants placed in extraction sockets might be caused by thread patterns and surface characteristics. It is proposed that future studies investigate the outcomes of the fresh socket to replace anterior teeth with “Dio” implants compared with other brands.

A limitation of this study was the small sample size. Another limitation was related to retrospective studies that lack control for confounding factors. An attempt was made to neutralize the effect of confounders using ANCOVA. Hence, controlled clinical trials are proposed to evaluate the effect of prosthetic characteristics and pre-extraction attached gingival width on the results of implants placed in fresh sockets.

5. Conclusion

Under the limitations of this study, it can be concluded that

- Fresh socket implant placement replacing both anterior and posterior teeth showed comparable results.
- Deeper PDs were found around restorations with a finish line site > 1.5 mm subgingivally.
- Sufficient attached gingiva was a more effective factor on PD than keratinized gingiva.
- Implants with more plaque scores showed more MBL.

CRediT authorship contribution statement

Roohollah Naseri: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Sepideh Asadollahi:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Validation, Visualization, Writing – review & editing. **Mohammadjavad Shirani:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Narges Pouremadi:** Data curation, Investigation, Methodology, Project administration, Software, Supervision, Validation, Visualization, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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