

Original Article

Esthetics and efficacy of dentition defects repaired by dental implantation

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Abstract: Objective: This study aimed to investigate the restoration success rate and esthetic effect of dental implantation in repairing dentition defects and to analyze the risk factors of implant restoration associated complications. Methods: A total of 194 patients with dentition defects were randomly divided into the immediate restoration group (n=97, with 153 implants) and the delayed restoration group (n=97, with 156 implants) according the admission order. A 3-year follow-up was conducted after treatment. The overall restoration effect and the incidences of complications in two groups were analyzed statistically. Results: The restoration success rates of loading for 1, 2 and 3 years were 99.35%, 97.84% and 94.17% respectively, in the immediate restoration group and 99.36%, 97.14% and 94.07% respectively, in the delayed restoration group. There was no significant difference in the restoration success rate of loading between two groups. Compared with the delayed restoration group, patients in the immediate restoration group showed no differences in pink esthetic score (t=0.724, P=0.235) and white esthetic score (t=0.509, P=0.694). Bone resorption at 1- and 2-year follow-up were lower in the immediate restoration group than those in the delayed restoration group (t=9.762; t=3.694, both P<0.001). Conclusion: No significant difference exists in the restoration success rate and esthetic effect between the immediate restoration and the delayed restoration in case of strict grasp of indications, prudent operation, as well as active control of periodontal diseases.

Keywords: Implant restoration, dentition defect, pink esthetic score, white esthetic score, esthetic effect

Introduction

Dentition defect as a disease that severely affects patients' daily life and it has an influence on the facial appearance, while a severe defect can lead to language and mastication dysfunction as well as an imbalanced growth of good teeth [1]. Implant denture restoration is a preferred method for the treatment of dentition defects, by which patients' appearance, language and mastication functions can be effectively improved [2]. Conventional methods stipulate the need of implant implantation after 3 months to achieve proper osseointegration. With the development of clinical techniques and implant surface modification, more and more physicians choose immediate and early implantation of implants.

A number of high-quality randomized controlled trials have reported a very high survival rate of

dentures by immediate implantation, and the successful rate in some studies is even high to 100%; immediate implantation shortens the treatment time and is good for both patients and dentists [3]. However, the results about marginal bone horizontal changes, implant stability and detection depth in a majority of studies are inconsistent, given that this is related to the high heterogeneity of descriptions of soft tissue conditions and the subjectivity of outcome measurements. The factors influencing the therapeutic effect of implant denture restoration are complex, and there are a great variety of implant systems. The short-term and long-term effects and prognosis of immediate implantation restoration and delayed implantation restoration are still controversial [4]. In this study, the clinical and esthetic effects of immediate and delayed implantation restoration were comparatively analyzed.

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Materials and methods

Patients

This study was approved by the Ethics Committee of Wuxi Stomatology Hospital. All patients signed the informed consent form.

A total of 194 patients were recruited in this study since July 1, 2014. They were divided into two groups according the admission order to receive immediate implantation restoration (153 implants in the immediate restoration group) and delayed implantation restoration (156 implants in the delayed restoration group), with 97 patients in each group. There were 113 females and 81 males ranging from 25-75 years old, with an average age of 48.8 ± 13.7 .

Inclusive criteria: patients with an age of 20-80 years; patients who had adjacent teeth mobility \leq I level; patients without deep overbite jaw; patients who participated in this study voluntarily [5]. Exclusive criteria: patients with alveolar bone resorption of adjacent teeth greater than one third of the root length; patients who had severe periodontal diseases or organic disease of vital organs; patients who had a serious smoking habit (more than 20 cigarettes/day); patients who suffered from epilepsy, mental disorders and psychological disease; patients who showed poor compliance to treatment.

Methods

Patients were asked about their medical history before surgery and received routine specialist examination, liver and renal function examination, and oral imaging examination.

Implantation operation was as follows. The skin around the mouth and intraoral tissues were disinfected. Surgical drape was spread for aseptic operation. Local anesthesia was performed with Articaine Hydrochloride and Epinephrine Tartrate Injection (PRODUITS DENTAIRE PIERRE ROLLAND, France). An H- or L-shaped incision was routinely. Cut at the alveolar ridge crest Bone mucosa was stripped to expose the alveolar bone. A pioneer drill was used to enlarge the hole at the top of the alveolar bone to the pre-established diameter and depth. Bone debris was collected during operation for subsequent filling. STRAUMANN implant was imbedded following

the removal of the injured tooth, and the sealing screw or healing abutment (Straumann, Switzerland) was placed. Temporary crown restoration was carried out within 48 h after implantation in the immediate restoration group and 3 months after implantation in the delayed restoration group. Permanent restoration was conducted for all patients after wearing the temporary crown for 6 months.

After treatment, a physician trained for clinical study carried out a 3-year telephone follow-up to analyze and summarize the implant bone resorption, overall restoration result and complications of patients in two groups [4]. The emergency protocols for common complications in oral restoration were formulated to treat in a timely manner the complications that occurred during follow-up [5].

Outcome measurements

General data included age, gender, course of disease, defect site, number of defects, and causes of dentition defect. Main outcome measurement was restoration success rate. A successful restoration must meet all of the following criteria: no significant difference between dentures and good teeth; stable dentures without displacement or loosening; no mucosal suppuration, swelling or pain; remarkable improvement of language or mastication function [6].

Other evaluation indicators included implant stability quotient (ISQ), esthetic effect, denture osseointegration, marginal bone resorption, and the incidences of complications (incidence of complication = number of patients with complications/total number of patients * 100%) [2, 4]. Esthetic effect was evaluated by pink esthetic score (PES) and white esthetic score (WES) [2]. Denture osseointegration and marginal bone resorption were assessed by X-ray film; the condition was expressed as the mean value of bone resorption at the middle and distal part of dentures by taking the implant-abutment tooth connection point as the reference point. To adjust the size distortion and enlargement of X-ray film, the actual size of implant was compared with the size of implant measured on the X-ray film.

Evaluation of denture complications involved mechanical complications and biological complications. The latter mainly included wound

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Table 1. Comparison of general data before treatment

	Immediate restoration group	Delayed restoration group	Statistical value (t/ χ^2)	P
Gender			0.191	0.662
Male	42	39		
Female	55	58		
Age (year)	48.5±14.1	49.2±13.3	0.356	0.639
Course of disease (month)	37.3±11.7	39.5±12.6	1.260	0.895
Defect site (number of teeth)			1.342	0.719
Upper anterior teeth region	24	23		
Upper posterior teeth region	39	46		
Lower anterior teeth region	17	21		
Lower posterior teeth region	73	66		
Causes of defect (number of teeth)			1.384	0.501
Dental caries	103	95		
Periodontal disease	27	33		
Other	23	28		
Number of tooth loss (number of teeth)			0.090	0.956
1	63	61		
2	27	28		
3	12	13		

dehiscence, peri-implantitis, gingival mucosal suppuration, swelling and pain, gingival bleeding, soft tissue atrophy, and the former mainly includes screw or abutment loosening, prosthesis fracture or exfoliation, and porcelain crown cracking. The complication was identified according to the medical records, clinical images, periapical X-ray film, panoramic X-ray film, and clinical indicators [6].

Statistical analysis

STATA 14.0 software was employed to analyze the data, and GraphPad Prism v 7.0 was used to illustrate the results. The measurement data were expressed as mean \pm standard deviation ($\bar{x} \pm sd$). The measurement data that conformed to a normal distribution between two groups were compared by t test and represented by t. The enumeration data were expressed as number of patients, and the difference between groups was analyzed by rank sum test, chi-square test, or Fisher's exact test. Influence factors of complications of denture restoration were analyzed by logistic regression analysis. $P < 0.05$ was generally considered statistically significant.

Otherwise, for patients in three groups, chi-square test was used for pairwise comparison,

and the significant level was adjusted: where $P < 0.017$ showed a significant difference.

Results

General data

There were 153 dentures in the immediate restoration group and 156 dentures in the delayed restoration group. No significant differences existed in age, gender, course of disease, defect site, causes of dentition defect and number of dentition defects between the two groups (all $P > 0.05$, **Table 1**).

Restoration success rate

A total of 42 patients with 71 dentures (19 patients with 33 dentures in the immediate restoration group and 23 patients with 38 dentures in the delayed restoration group) in two groups could not be contacted during the 3-year follow-up. The rate of patients lost to follow-up was 21.65%, and the percentage of their dentures was 22.98%. The restoration success rates of loading for 1, 2 and 3 years were 99.35%, 97.84% and 94.17% respectively, in the immediate restoration group and 99.36%, 97.14% and 94.07% respectively, in the delayed restoration group. There was no

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Table 2. Comparison of restoration success rate of dentition defect

	1 year	2 years	3 years
Immediate restoration group	152/153 (99.35%)	136/139 (97.84%)	113/120 (94.17%)
Delayed restoration group	155/156 (99.36%)	136/140 (97.14%)	111/118 (94.07%)
Statistical value			0.001
P	1.000	1.000	0.974

Table 3. Comparison of esthetic effect and stability of dentition defect restoration

	Immediate restoration group	Delayed restoration group	Statistical value (t)	P
PES	11.35±1.29	11.24±1.38	0.724	0.235
WES	8.34±1.31	8.42±1.45	0.509	0.694
ISQ	69.73±7.58	68.49±7.24	1.471	0.071

Note: PES: pink esthetic score; WES: white esthetic score; ISQ: implant stability quotient.

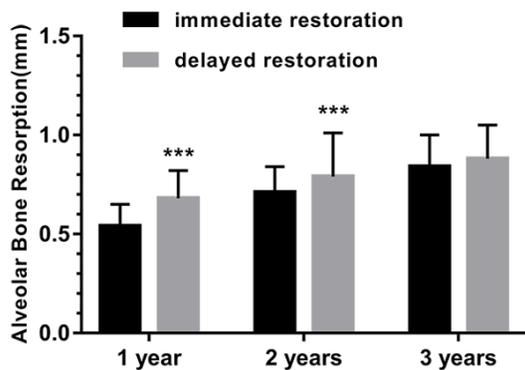


Figure 1. Comparison of alveolar bone resorption around the denture. Compared with immediate restoration group, ***P<0.001.

significant difference in the restoration success rate of loading for 3 years between the two groups (P>0.05, **Table 2**).

Restoration effect

PES, WES and ISQ of patients in both groups were shown in **Table 3**. Alveolar bone resorption around the denture was increasing after loading for 1, 2 and 3 years in both groups (**Figure 1**). The alveolar bone resorption around the denture after loading for 1 and 2 years was lower in the immediate restoration group than that in the delayed restoration group (t=9.762, t=3.694; both P<0.001). There was no significant difference in the alveolar bone resorption around the denture after loading for 3 years

between two groups (t=1.870, P=0.063, **Table 4**).

Complications

The number of biological complications was 23 (15.03%) in the immediate restoration group and 21 (13.46%) in the delayed restoration group. There were no significant differences in common complications of wound dehiscence (5 vs. 6), peri-implantitis (8 vs. 7), gingival bleeding (3 vs. 2), and gingival pain (3 vs. 3) between two groups ($\chi^2=0.156$, P=0.693). The number of mechanical complications was 21 (13.73%) in the immediate restoration group and 19 (12.18%) in the delayed restoration group. There were no significant differences in common complications of screw or abutment loosening (9 vs. 8), prosthesis fracture or exfoliation (3 vs. 3), and porcelain crown cracking (5 vs. 4) between the two groups ($\chi^2=0.164$, P=0.686).

The incidence of complications caused by different causes of defects showed a significant difference between the two groups ($\chi^2=89.773$, P<0.001). The incidence of implant restoration related complications in patients with periodontal disease was higher than those with dental caries and other causes ($\chi^2=91.231$, $\chi^2=18.818$, both P<0.017). There was a difference in the incidence of implant restoration related complications between patients with different number of teeth lost ($\chi^2=35.230$, P<0.001). A further pairwise comparison showed that patients with dentition defects due to the absence of 3 teeth were significantly more than those with the absence of 1 or 2 teeth ($\chi^2=35.947$, $\chi^2=7.766$, both P<0.017, **Table 5**).

A regression analysis was carried out by taking the occurrence of implant restoration related complications as the dependent variable and taking age, gender, load duration (month), clinical crown-root ratio, implant length (mm), causes of defect, and number of teeth lost as

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Table 4. Comparison of alveolar bone resorption around the denture (mm)

	1 year	2 years	3 years
Immediate restoration group	0.54±0.11	0.71±0.13	0.84±0.16
Delayed restoration group	0.68±0.14	0.79±0.22	0.88±0.17
Statistical value	9.762	3.694	1.870
P	<0.001	<0.001	0.063

the independent variables. Age, cause of defect and number of teeth lost were independent influencing factors for the occurrence of implant restoration related complications. Patients aged over 60, periodontal disease, number of teeth lost of 2 and 3 were risk factors for the occurrence of implant restoration related complications (odds ratio =4.419, 2.568, 3.714 and 4.559, respectively, **Table 6**).

Discussion

Implant restoration preserves healthy adjacent teeth and ensures the integrity of natural dentition, the similarity of implants' shape, color and size to nature teeth, good biocompatibility and mastication function, and the coordination of implants with healthy adjacent teeth [7]. Moreover, the implant denture is characterized by lightness, stabilization and durability which can effectively avoid the disadvantages of conventional dentures, such as gingival irritation, articulation disorder, pain and poor tightness, and it improves patients' comfort and satisfaction, which has been widely recognized [8]. Implant restoration technique is a mature technique with a high success rate, and a large number of studies have reported that the 10-year implant survival rate is over 90% [9].

Immediate restoration has several advantages over delayed restoration: firstly, it can avoid secondary iatrogenic injury, reduce discomfort during treatment, shorten course of treatment and restore the physiology of teeth quickly; secondly, it reduces the exposure of the alveolar bone and prevents the resorption of alveolar ridge; thirdly, and fourthly, it maintains the amount of soft tissues and averts atrophy; fifthly, it is easy to locate implants, as a consequence, the implant is more compatible with the adjacent teeth [10]. In this study, no significant difference was found in the restoration success rate of loading for 3 years between the

immediate restoration group and the delayed restoration group, which might be related to the higher requirements for indications of immediate restoration [2, 6, 9].

The foundation of dental implants is osseointegration, that is, osteoblasts grow and bind directly to the titanium surface of the implant in the alveolar bone. Good osseointegration is the key to implant restoration. Osteoporosis, diabetes, and other unhealed oral diseases can lead to poor primary stability of implants, and undesirable osseointegration results in implantation failure [11-13]. In this study, patients in the immediate restoration group had good denture osseointegration, and no significant X-ray perspective region was observed around the denture. The alveolar bone resorption after loading for 1, 2 and 3 years was 0.54±0.11 mm, 0.71±0.13 mm, and 0.84±0.16 mm respectively, in the immediate restoration group and 0.68±0.14 mm, 0.79±0.22 mm, and 0.88±0.17 mm in the delayed restoration group, respectively. There was a significant difference in the alveolar bone resorption within 2 years after loading, which might be due to the fact that immediate restoration caused less exposure of alveolar bone than delayed restoration [14]. Besides restoration duration, risk factors that had a significant impact on bone resorption level included autoimmune disease, heavy smoking, bisphosphonate therapy, implanting site, diameter, design, and the presence of bone defects at the implanting site. The difference in bone resorption between the two groups was decreasing with the lengthening of loading duration [15, 16].

Esthetic effect is a key evaluation indicator. Soft tissues around the prosthesis in the immediate restoration group were reconstructed rapidly due to the early wearing a dental crown, whereas soft tissues might change color because of squeezing. In this study, no significant differences were found in PES and WES between the immediate restoration group and the delayed restoration group, while PES in immediate restoration group was slightly higher. This was the same result as the study by Arora et al., who considered that restoration duration appeared to play a positive impact on the esthetic effect of immediate implant, and the median of PES in the immediate restor-

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Table 5. Comparison of influence factors of implant restoration related complications

Factors	Complications		Statistical value	P
	No	Yes		
Gender [#]			0.270 (0.004)	0.603 (0.950)
Male	56 (92)	25 (34)		
Female	82 (133)	31 (50)		
Age (year)			8.254	0.004
≤60	101	29		
>60	37	27		
Load duration (month)	30.4±8.7	32.3±7.9	1.414	0.159
Clinical crown-root ratio	1.26±0.35	1.32±0.36	1.073	0.285
Implant length (mm)	10.32±1.71	10.40±1.83	0.365	0.716
Defect site (number of teeth)			1.477	0.478
Upper anterior teeth region	39	8		
Upper posterior teeth region	64	21		
Lower anterior teeth region	28	10		
Lower posterior teeth region	104	35		
Causes of defect (number of teeth)			89.773	<0.001
Dental caries	175	23		
Periodontal disease	16	44		
Other	34	17		
Number of tooth loss (number of teeth)			35.230	0.001
1	110	14		
2	38	17		
3	9	16		

Note: [#]Number of patients with tooth loss (number of teeth lost).

Table 6. Logistic regression analysis of related factors of implant restoration complications

Factors	B	SE	Wald χ^2	df	P	OR
Gender	0.018	0.453	0.002	1	0.968	1.018
Age (year)	1.486	0.716	4.307	1	0.038	4.419
Load duration (month)	0.673	0.542	1.542	1	0.214	1.960
Clinical crown-root ratio	-0.136	0.195	0.486	1	0.486	0.873
Implant length (mm)	-3.733	2.358	2.506	1	0.113	0.024
Causes of defect			7.403	2	0.007	
Periodontal disease	0.943	0.312	9.135	1	0.003	2.568
Other	0.582	0.574	1.028	1	0.311	1.790
Number of tooth loss			9.388	2	0.002	
2	1.312	0.341	14.803	1	<0.001	3.714
3	1.517	0.543	7.805	1	0.005	4.559
Constant	-5.724	1.521	14.163	1	<0.001	0.003

Note: SE: standard error; df: degrees of freedom; OR: odds ratio.

ation group was higher than that in the delayed restoration group [2]. Although restoration duration had no significant effect on PES, the height of distal papilla was higher in immediate restoration group. In this study, patients in the

immediate restoration group had a higher ISQ than the delayed restoration group, which might be due to the fact that delayed restoration referred to the implant implantation after healing of tooth extraction wounds and immediate

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restoration referred to the immediate implant implantation after tooth extraction. In these two cases, the alveolar bone did not suffer much damage, so there was no significant difference in implant stability after implantation. Immediate implant implantation was conducive to reducing alveolar bone resorption. The prosthesis could act as an early support to induce the formation of gingival tissue, thus inhibiting labial gingival recession.

The restoration success rate was related to multiple factors, including age, implant diameter and length, periodontal disease and surgical procedures. Multi-factor Cox regression analysis by Takashima et al. showed that male and maxillary removable prosthesis were risk factors causing implantation failure [17]. The survival rate of dentures in males was significantly lower than that in females (86.9% vs. 99.1%). The harmful effect of smoking on oral health was well recorded in the literature. Smoking increased the expression and sedimentation of advanced glycosylation end products in the periodontal tissue and then upregulated the pro-inflammatory cytokine levels (matrix metalloproteinase-1, interleukin-1 β , and interleukin-6), promoting the development of tissue damage, periodontal disease and the alveolar bone resorption [18, 19]. Elderly patients with dentition defects are a special group, whose oral restoration manifestations have unique characteristics. Patients with older age show a trend of have longer healing time, more risk factors affecting their overall health, lowered bone mineral density, thinned cortical bone, and lower restoration success rates [13].

Periodontal disease is well known to be an important risk factor for dentition defects or tooth loss. Host immune inflammatory response caused by bacterial colonization leads to the release of multiple inflammatory mediators, resulting in connective tissue destruction and bone resorption and increasing difficulty in dental restoration and treatment [20, 21]. Therefore, for patients with periodontal disease, it is necessary to pay special attention during surgery to the distance between injured tooth and implant and to timely correction of the adjacent tooth with alveolar bone of poor shape. Some scholars considered that immediate implant therapy caused higher incidence of postoperative inflammation and easily brought issues of delayed wound closure and early

implant instability. Although no significant difference was found in incidence of complications between two therapy methods in this study, many studies reported a higher incidence of complications by immediate restoration compared with delayed restoration [4]. The implantation region was regarded as a contaminated wound, and immediate restoration had the probability of increasing bone grafting infection. Therefore, it is recommended to choose delayed restoration.

Some patients might experience restoration failure due to denture restoration surgery and various postoperative complications [22, 23]. Biological complications (such as soft tissue atrophy, abnormal color and visible crown margin) often occurred in the anterior region of dentition, and mechanical complications (such as screw loosening and fracture, and porcelain crown cracking) mostly occurred in the posterior region of dentition. Mechanical complications were most likely to occur within 2 years of functional loading (as opposed to biological complications). Attention must be paid to the standard surgical operation during treatment. Wilson reported that peri-implant diseases were caused by excessive cement in 81% of implant restoration dentures, and among these patients, peri-implantitis occurred in 20%-56% of patients and 10%-43% of implants [24]. In addition, improper application of force during treatment or excessive load stress of implants could cause bone destruction around the implant, affecting osseointegration. Minimally invasive tooth extraction techniques maintain the morphological structure of soft and hard tissues in the implantation region to the greatest extent and helps reconstruct the adherent soft tissues.

Other factors that could contribute to the success of implantation included the experience of implantation operator, nutritional status of patients, oral health status before and after implantation, drilling speed, and the use of a blunt drill. These variables need to be strictly controlled, and studies with a larger sample size are needed [25].

In this study, a prospective method was used to compare the restoration success rate and esthetic effect between immediate and delayed restoration. There were no significant differences in implant stability, esthetic effect

and complication incidence between the two groups, except the difference in marginal bone resorption within 2 years after restoration. Immediate and delayed restoration both work well if by following indications, prudent operation measures and active control of periodontal diseases can be achieved. In addition, a difference existed in the incidence of implant restoration complications among patients with different causes of defect and different number of teeth lost.

Disclosure of conflict of interest

None.

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