

## Original Article

# Efficacy of oral implant repair on dentition defect and effects on bone resorption and complications

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**Abstract:** Objective: This study aims to investigate the efficacy of oral implant repair on dentition defects, and the effects on bone resorption and complications. Methods: In this study, 166 patients with dentition defect were recruited in the First Affiliated Hospital of Xi'an Jiaotong University from January 2011 to January 2013. These patients were randomly divided into observation group (83 cases, 135 implants) and control group (83 cases, 139 implants). The observation group was given dental implants for repair, and the control group was received conventional repairs. After the treatment, a 5-year follow-up was performed. The bone resorption around the denture, the overall repair effect, and complications were statistically analyzed at the 1, 3, and 5 years' time points. Results: The bone resorption around the dentures was gradually increased in the two groups after repair. The bone resorption around the dentures in the observation group at the 1, 3, and 5 years was significantly lower than that in the control group (all  $P < 0.001$ ). The satisfaction scores of the observation group in terms of stability, chewing function, language function, aesthetics and comfort were significantly higher than those in the control group (all  $P < 0.001$ ). After treatment, the incidences of gum bleeding, tooth pain and screw or abutment loosening in the observation group were significantly lower than those in the control group (all  $P < 0.05$ ). Conclusion: Oral implant repair in patients with dentition defects received better short- and long-term repair efficacy, lower incidence of complications when compared with conventional repair. It is worth promoting in clinical treatments in the future.

**Keywords:** Dental implant repair, dentition defect, clinical effect, bone resorption, short- and long-term efficacy and prognosis

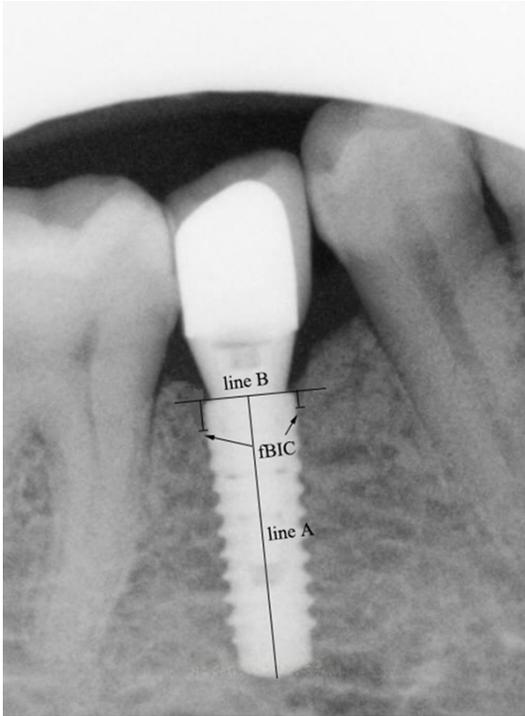
## Introduction

As a disease that seriously affects the patient's daily life, dentition defect is unfavorable for the normal work of the patient's digestive system, and can cause facial aesthetic troubles. In severe cases, it also affects the patient's language function, chewing function, and results in the emergence of growth imbalance for other healthy teeth [1]. Although the prevalence of tooth loss has declined in the past decade, it is still the world's major oral disease [2].

Denture restoration has become the preferred treatment for dentition defects. It effectively improves the aesthetics and function. Methods for repairing the missing teeth include remov-

able partial dentures, implant dentures, and fixed dentures. However, due to the unstable loss of teeth caused by alveolar bone resorption, the traditional prosthodontics, especially the low dentures, it could affect the patient's comfort, chewing, speaking ability and aesthetics [3, 4]. The factors affecting the efficacy of implant denture restoration are complex, and there are various types of implant systems. Moreover, the short- and long-term efficacy and prognosis of defect repair on implant systems varies among different reports.

In this study, conventional repair was used as a control treatment to investigate the efficacy of oral implant repair on the repair of dentition defects, bone resorption and complications.



**Figure 1.** Measurement of bone resorption around the denture.

### Materials and methods

#### *Patient information*

This study has got approval from local Ethics Committee of the First Affiliated Hospital of Xi'an Jiaotong University. The patients understood and signed the informed consent. A total of 166 patients with dentition defects were recruited in the First Affiliated Hospital of Xi'an Jiaotong University from January 2011 to January 2013, including 95 females and 71 males (mean age 49.27 years old, from 25 to 75 years old). The inclusion criteria were consisted of (A) range from 20 to 80 years old; (B) loosening of adjacent teeth  $\leq$  degree 1; (C) no deep overbite; (D) voluntary participation in this study [5]. The exclusion criteria consisted of (A) the absorption of the adjacent alveolar bone greater than  $1/3$  of the teeth's root length; (B) severe periodontal disease or major organ disease; (C) severe smoking habits (greater than 20/day); (D) suffering from mental and psychological diseases; (E) poor adherence to treatment. According to the admission order, they were randomly divided into observation group (83 cases, 135 implants) and control group (83 cases, 139 implants). The observation group

was given dental implants for repair, and the control group was received conventional repairs.

#### *Methods*

The control group was subjected to conventional repair as follows [3]. The patient's oral skin and cavity tissues were strictly sterilized, and aseptically drape the towel. Then 0.8% procaine hydrochloride (specification: 0.1 g/20 mL, Xudong Haipu, China) was used for local anesthesia. The patient's residual tooth was cleaned, and the extracted tooth was healed to prepare the prepared teeth. Finally, the prepared tooth model was worn to the patient.

The observation group was performed oral implant repair as follows [6]. The patient's oral skin and cavity tissues were strictly sterilized, and aseptically drape the towel. Then 0.8% procaine hydrochloride (Xudong Haipu, China) was used for local anesthesia. H or L-shaped incision was performed in the alveolar ridge top line. Then bone mucosa was peeled of the bone, and alveolar bone was exposed. In accordance with the preset diameter and depth, a pilot drill was used at the top of the alveolar bone for reamer drilling. This surgery need to collect debris for later filling. Then implant teeth were fixed in oral and sealing screw or healing abutment was placed in the location.

After the treatment, a physician who was trained in clinical research conducted a five-year follow-up by telephone. Moreover, the implant bone resorption, overall repair effect, and complications of the two groups at 1, 3, and 5 years after the repair were determined and analyzed respectively. Contingency plans for common complications of oral rehabilitation were formulated, and the complications of patients were treated during follow-up period timely [7].

#### *Outcome measures*

Baseline data included age, gender, duration of disease, defect sites, number of defects, and causes of dentition defect. The main outcome measure was the success rate of repair. The secondary outcome measure was the overall repair effect and denture complications.

Main outcome measures were as follows. Standards for successful repair included: (A) there was no significant difference between dentures

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**Table 1.** Comparison of clinical baseline data between two groups

Item	Observation group	Control group	t/ $\chi^2$ /Z	P
Gender (n)			0.221 <sup>#</sup>	0.754
Male	37	34		
Female	46	49		
Age (years old)	49.6±13.8	48.7±14.2	0.675*	0.512
Disease course (months)	36.6±13.8	38.1±14.7	0.518*	0.627
Clinical crown to root ratio	1.3±0.2	1.4±0.2	0.160*	0.875
Implant length (mm)	10.3±1.7	10.6±1.8	0.559*	0.592
Receptor site partition (n)			0.381 <sup>#</sup>	0.948
Upper anterior area	21	23		
Upper back area	38	36		
Lower anterior area	11	14		
Lower back teeth area	65	66		
Defect cause (n)			1.818 <sup>#</sup>	0.407
Tooth decay	93	85		
Periodontal disease	22	29		
Other	20	25		
Number of missing teeth (n)			0.156 <sup>*</sup>	0.876
One	37	40		
Two	31	30		
Three	12	13		

Note: <sup>#</sup>Chi-square test: statistical value is  $\chi^2$ ; \*t test: statistical value is t; <sup>\*</sup>rank sum test: statistical value is Z.

**Table 2.** Comparison of the effect of one-year repair between two groups

Item	Observation group	Control group	t	P
Stability	7.94±0.97	6.57±0.52	15.543	<0.001
Language features	9.35±0.97	8.26±0.89	8.213	<0.001
Chewing function	8.58±1.04	7.56±1.12	8.535	<0.001
Aesthetics	9.12±0.68	8.36±0.75	10.957	<0.001
Comfort	8.84±1.32	6.46±0.79	6.743	<0.001
Overall satisfaction	9.11±0.92	7.83±0.85	7.352	<0.001

and normal teeth; (B) dentures were stable, no displacement or loosening; (C) no mucopurulent, swelling or pain; (D) chewing or language function was significantly improved [8]. It was defined as fail repair if none of the above was observed. Repair success rate = (repaired denture number/total number of dentures) \* 100%.

Secondary outcome measures were as follows. One year after treatment, the overall repair effect evaluation included five aspects: stability, chewing function, language function, aesthetics, and comfort [9]. Each item contains 10

points. The overall satisfaction was 10 points and accessed by visual analog scale. The osseointegration of the dentures and the marginal bone resorption were evaluated by X-ray films. The images were processed using CDR Dicom software. The longitudinal axis of the implants was line A (**Figure 1**). The vertical line (line B) of the implant-abutment connection was made by line A. The amount of bone resorption at the edge of the denture was measured from the fBIC to line B distance of the alveolar bone-implant connection point. The average of multiple measurements was taken as the result [10].

In order to adjust the dimensional distortion and enlargement of the X-ray film, the actual size of the implant was compared with the implant size which measured on the X-ray film [4]. Denture complication evaluation included mechanical complications and biological complications. Biological complications included wound dehiscence, inflammation around the prosthesis, gingival mucous membrane suppuration, swelling, pain, bleeding gums, soft tissue atrophy and so on. Mechanical complications mainly included loose screws or abutments, broken

or detached restorations, porcelain crown cracking, etc. According to the patient's treatment records, clinical photos, X-ray films around the root tip, panoramic X-ray films and clinical indicators, those complications were identified [11].

### Statistical analysis

SPSS 14.0 software was used for statistical analysis. The measurement data was expressed as mean ± standard deviation ( $\bar{x} \pm sd$ ). The measurement data with normal distribution

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**Table 3.** Comparison of repair success rate of dentition defect in two groups

Item	One year	Three years	Five years
Observation group	134/135 (99.26%)	120/123 (97.56%)	108/111 (97.30%)
Control group	130/139 (93.53%)	105/126 (83.33%)	73/112 (65.18%)
$\chi^2$	0.119	1.359	3.939
P	0.796	0.244	0.047

**Table 4.** Comparison of bone resorption around the denture in two groups (mm)

Item	One year	Three years	Five years
Observation group	0.54±0.11	0.71±0.13	0.84±0.17
Control group	1.36±0.24	1.57±0.32	1.85±0.37
t	15.236	12.873	16.681
P	0.000	0.000	0.000

was conducted with t test. The count data was expressed by percentage, and compared with  $\chi^2$ , rank-sum test, or Fisher's exact test. The Pearson correlation in SPSS software was used to analyze the correlation between the indicators of two groups. Multivariate Logistic regression was used to analyze the correlation between multiple factors and the complications of denture. Generally,  $P < 0.05$  indicates statistically significant difference. In the pairwise comparison between the three groups of chi-square tests,  $P < 0.017$  is considered statistically significant.

### Results

#### *Comparison of baseline data between two groups*

The age, gender, disease duration, clinical crown-to-root ratio, receptor site zoning, length of implant, cause of dentition defect, and number of dentition defects in the two groups were analyzed (**Table 1**). There were no statistical differences in baseline indicators between the two groups (all  $P > 0.05$ ).

#### *Overall repair efficacy*

The differences in stability, chewing function, language function, aesthetics, comfort, and overall satisfaction between the two groups were statistically significant (all  $P < 0.001$ , **Table 2**).

#### *Repair success rate*

After 5 years of follow-up, 35 patients (51 implants in total) could not be contacted in the two groups. The loss rate was 21.08%, and the loss rate of implants was 18.61%. In the

observation group, the repair success rates of the patients at 1, 3, and 5 years were 99.26%, 97.56%, and 97.30%, respectively. In the control group, the success rates of the 1, 3, and 5 years were 93.53%, 83.33%, and 65.18%, respectively. There was a statistically significant difference between the two groups in the repair success rate of the 5-year load ( $\chi^2 = 3.939$ ,  $P < 0.05$ , **Table 3**).

#### *Bone resorption around the denture*

In the observation and the control group, the bone resorption around the denture at 1, 3, and 5 years increased gradually. In the observation group, the bone resorptions around the denture were all lower than that in the control group (all  $P < 0.001$ , **Table 4**).

#### *Incidence of complications*

The incidence of biological complications in the observation group and the control group were 14.07% and 33.09%, respectively, and the difference was statistically significant ( $\chi^2 = 16.256$ ,  $P < 0.001$ , **Table 5**). The incidence of mechanical complications in the observation group and the control group were 12.59% and 36.69%, respectively, and the difference between the two groups was statistically significant ( $\chi^2 = 18.417$ ,  $P < 0.001$ , **Table 5**).

A comparison of the influencing factors of implant complications found that there was a significant difference in the incidence of complications in patients with different causes of defect ( $\chi^2 = 52.846$ ,  $P < 0.001$ ). Thus, further comparisons were made between different causes. The results showed that the incidence of complications of implant repair in patients with periodontal disease was higher than that in patients with caries or other causes ( $\chi^2 = 53.936$  and  $\chi^2 = 11.725$ , both  $P < 0.017$ ). There was also a significant difference in the incidence of implant repair complications among

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**Table 5.** Comparison of repair complications between the two groups (n, %)

Item	Observation group (n=135)	Control group (n=139)	$\chi^2$	P
Biological complications	19 (14.07%)	46 (33.09%)	16.256	<0.001
Wound cracking	4 (2.96%)	5 (3.60%)		1.000*
Prosthetic inflammation	6 (4.44%)	12 (8.63%)	1.957	0.162
Gingival bleeding	2 (1.48%)	11 (7.91%)	6.269	0.012
Toothache	3 (2.22%)	11 (7.91%)	4.575	0.032
Other	4 (2.96%)	7 (5.04%)	0.764	0.382
Mechanical complications	17 (12.59%)	51 (36.69%)	18.417	<0.001
Loose screws or abutments	7 (5.19%)	21 (15.11%)	5.453	0.020
Restoration or breakage of the restoration	3 (2.22%)	10 (7.19%)	3.746	0.053
Porcelain crown collapse	5 (3.70%)	7 (5.04%)	0.290	0.590
Other	2 (1.48%)	13 (9.35%)	8.199	0.004

Note: \*Analysis using Fisher's exact test.

**Table 6.** Comparison of factors influencing the occurrence of complications in implant repair

Item	Complications		$t/\chi^2/Z$	P
	No	Yes		
Gender (n)			0.116	0.734
Male	27	10		
Female	32	14		
Age (years-old)			5.473	0.019
≤60	45	12		
>60	14	12		
Disease course (months)	30.2±7.9	32.4±8.3	1.831	0.083
Clinical crown to root ratio	1.37±0.35	1.64±0.39	0.417	0.691
Implant length (mm)	10.3±1.7	10.6±1.8	1.984	0.076
Receptor site partition (n)				0.934
Upper anterior area	16	5		
Upper back area	27	11		
Lower anterior area	9	2		
Lower back teeth area	47	18		
Defect cause (n)			52.846	0.000
Tooth decay	83	10		
Periodontal disease	3	19		
Other	13	7		
Number of missing teeth (n)			8.369	0.015
One	33	4		
Two	24	7		
Three	6	6		

patients with different numbers of missing teeth ( $\chi^2=8.369$ ,  $P<0.05$ ). Further comparisons were made between different numbers of missing teeth. The results showed that patients with a defect number of three were significantly larger than those with a defect number of one ( $\chi^2=8.572$ ,  $P=0.003$ , **Table 6**).

Whether the complications occurring of implant repair were defined as the dependent variables. Gender, age, loading time (month), clinical crown-to-root ratio, implant length (mm), cause of defect, and number of missing teeth were taken as independent variables for regression analysis. After controlling for other factors, the age, cause of the defect, and number of missing teeth are independent influencing factors for the occurrence of complications in implant repair. Among them, patients aged over 60, periodontal disease, number of missing teeth (2 and 3) were risk factors for the occurrence of complications after implantation (OR=4.464, 2.693, 3.543, and 4.446, respectively). Implant length was a protective factor for the occurrence of complications in implant repair (OR=0.067, **Table 7**).

### Discussion

In the past decade, with the advancements of science and technology as well as the continuous developments of medical equipment, clinical prosthetics have been significantly improved and developed [12]. Planting and restoration preserves healthy neighboring teeth, ensures the integrity of the natural dentition. Those teeth which have similar shape, color and size with natural teeth, show good biocompatibility,

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**Table 7.** Logistic regression analysis of related factors in implantation and repair complications

Item	B	SE	Wald $\chi^2$	df	P	OR
Gender (n)	0.017	0.416	0.002	1	0.967	1.017
Age (years-old)	1.496	0.744	4.040	1	0.044	4.464
Disease course (months)	0.578	0.505	1.310	1	0.259	1.782
Clinical crown to root ratio	-0.026	0.092	0.077	1	0.781	0.975
Implant length (mm)	-2.705	1.126	5.771	1	0.021	0.067
Defect cause (n)			7.403	2	0.007	
Periodontal disease	0.991	0.307	10.408	1	0.001	2.693
Other	0.505	0.534	0.894	1	0.344	1.657
Number of missing teeth (n)			9.388	2	0.002	
Two	1.265	0.335	14.259	1	0.000	3.543
Three	1.492	0.540	7.634	1	0.005	4.446
Constant	-4.607	1.496	9.484	1	0.002	0.010

chewing function, and harmonization with adjacent healthy teeth. At the same time, the implant denture is light, stable, and durable. It can effectively avoid the shortcomings of conventional dentures such as gingival irritation, dysphonia, pain, poor adhesion, and improve the patient's comfort and satisfaction. It has been widely recognized now [13-15]. In this study, the repair effect was evaluated from the aspects of retention function, language function, chewing function, aesthetics, comfort, and overall satisfaction. The effect of implant restoration was significantly better than that of conventional repair methods.

In recent years, the long-term efficacy of oral rehabilitation has been continuously improved, and numerous studies reported that the 10-year planting survival rates were over 90% [14]. This study found that the success rate of the implanted patients in the observation group at 1, 3, and 5 years was 99.26%, 97.56%, and 97.30%, respectively, which were basically consistent with Tallarico et al. [16]. The success rate of implant repair is related to a variety of factors, including age, implant diameter and length, periodontal disease, and surgical operations [17, 18]. Alqutaibi et al. compared the aesthetics, implant failure rate, patient satisfaction, complications, and bone loss around the implant in single versus two-implant mandibular overdentures [18]. Meta-analysis in that study showed that, the 1-year planting failure rate of two implants were higher than the single implant overdentures. This was basically consistent with the results of this study. Moreover,

in this study, the number of different missing teeth was an independent factor that affect the occurrence of complications in implant repair. The morbidity of defects with 2 and 3 teeth were relative to the number of defects with a defect of 1 tooth in patients (OR=3.543 and 4.446, respectively).

Patients with dentition defects in the elderly are a special group. The performance of dental restorations is unique. With the increase of age, the bone density of patients decreased, and the cortical bone thinned.

The success rate of bone cultivation showed a downward trend. AlZarea et al. found that all variables of functional limitations, somatic pain, mental discomfort, physical disability, mental disability, and social disability were significantly reduced from baseline to 1st, 2nd, and 3rd year in patients undergoing implant repair [19]. It has been proved that the implant repair has a significant effect. It was worth noting that the differences in OHIP scores between the age groups of patients less than 60 years of age and over 60 years of age at the 1st, 2nd, and 3rd years were statistically significant. The reason is that young people are usually engaged in work and life, and they need to adapt to various social environments. The requirements for oral conditions are higher than those for older people [20, 21].

The relationship between implant length and planting success rate is controversial. The general point of view is that because the interfacial stress is related to the implant length, the overall success rate of short implants is lower than that of long implants. The former is suitable for lower alveolar bone of posterior teeth in defect repair [17]. In order to reduce implant stress, treatment is preferred for longer implants for patients with looser bones, especially in the maxillary posterior area [22]. However, some researchers hold different views. Esfahrood et al. found that the initial survival rate of short maxillary implants was independent of implant width, surface, or design, but the accumulation success rate of implants with short rough surfaces (especially less than 7 mm in length) was

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higher than that of the implant on the machined surface [23]. In addition, short implants with high crown-implant ratio (C/I) and occlusion table (OT) values did not seem to cause bone loss around the implant by increasing occlusal loading. Moreover, both shortened dental implants and bone augmentation could repair maxillary atrophy, but fewer dental implants had fewer biological complications [17].

It is well known that periodontal disease is an important risk factor for dentition defects or missing teeth. Periodontitis in patients with periodontitis causes sustained absorption of alveolar bone due to inflammation of the periodontium, and it is difficult to repair and treat the teeth. Patients with chronic periodontitis and accompanied dentition defect have significant implant osseointegration in the early stage after implant restoration. The short-term efficacy was more ideal [24]. However, long-term efficacy was significantly at a disadvantage because of the effect of peripheral bone resorption and attachment loss [24]. Therefore, for patients with periodontal disease, special attention should be paid to the distance between the affected tooth and the implant during the operation, and timely correction of the neighboring teeth with bad alveolar bone shape.

This study found that patients in the observation group had a good zygomatic osseous union with no significant X-ray area around the alveolar. The alveolar bone absorption at 1, 3, and 5 years were  $0.54\pm 0.11$  mm,  $0.71\pm 0.13$  mm, and  $0.84\pm 0.17$  mm, respectively. Whereas in the control group, the alveolar bone resorption at 1, 3, and 5 years were  $1.36\pm 0.24$  mm,  $1.57\pm 0.32$  mm, and  $1.85\pm 0.37$  mm, respectively. There were significance differences between two groups. Dental implants are based on osseointegration, which is the growth of osteoblasts and is directly associated with the titanium surface of alveolar bone implants [25]. Good osseointegration is the key to implant repair. Not cured osteoporosis, diabetes, and other oral diseases could result in poor initial stability of the implant, poor bone integration, and failure to implant [10].

Although denture restoration is commonly used and accepted, there are various complications and problems that may arise after surgery and postoperatively [14]. The dentition anterior

area often appears aesthetic complications (such as soft tissue atrophy, poor color, visible crown edge). The dentition posterior area appears more mechanical complications (such as screw loosening, screw fracture, porcelain crown cracking, etc.). Mechanical complications are most likely to occur within 2 years of functional loading (as opposed to biological complications) [11]. A previous study has shown that screw loosening was a major mechanical complication of implant-supported single-denture dentures [26]. The incidence of abutment screw loosening ranges from 2.4% to 37.7%. A review study found that cumulative 5-year complication rates for porcelain crown cracking and screw fracture were 7.8% and 1.3%, respectively [27]. This is mainly consistent with the findings of this study. In the implant repair group, there were 7 screws or abutment loosening with an incidence rate of 5.19%, while there were 5 cases with porcelain crown collapse with an incidence rate of 3.70%. Peri-implantitis was also a common complication, and there was no difference in the incidence between the observation group and the control group in this study. Wilson reported that in 81% of implanted dentures, 20 to 56% of patients and 10 to 43% of implants had peri-implantitis, due to excess cement causing implant-related disease [28]. Therefore, the treatment process should pay attention to the standard surgical operation. During cement fixation process, leaving too much cement can cause inflammation around the implant, promote alveolar bone absorption. In addition, improper treatment or implant stress loading can cause bone destruction around the implant and affect osseointegration [27].

Due to using forward-looking design and the limitations of the number of study cases in this study, it was impossible to perform more detailed analysis on many factors affecting the oral restoration effect [29]. Therefore, we will optimize the design of project, increase the number of cases to be studied, and thoroughly investigate the effects of factors such as missing tooth sites, defect levels, economic conditions, implant diameter, implant orientation, and orientation on clinical diagnosis and treatment choices and treatment effects in further studies [30, 31].

In conclusion, compared with conventional repair, oral implant repair in patients with denti-

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tion defects received better short- and long-term repair efficacy, lower incidence of complications. It is worth promoting in clinical treatment in the future.

### Disclosure of conflict of interest

None.

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