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Original Article

The application of locking-taper implants in posterior area implant restoration with insufficient occlusal-gingival distances

Guoxi Sun[1*], Lei Cao[2*], Haiying Zhang[1]

[1]Department of Stomatology, Jiaozhou Central Hospital of Qingdao, Qingdao, Shandong Province, China; [2]Department of Stomatology, Qingdao Stomatological Hospital, Qingdao, Shandong Province, China. [*]Equal contributors and co-first authors.

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Abstract: Objective: We aimed to investigate the effect of locking-taper implants on restoration in the posterior teeth area with insufficient occlusal-gingival distances. Methods: Forty-five patients undergoing dental implants in our hospital with occlusal-gingival distances under 5 mm in the posterior teeth area were recruited for this retrospective study. A total of 78 locking-taper implants were implanted in these patients. The patients were followed up for two years to observe the implant retention rate, the implant bone heights at different time points after the restoration, and the effects of the different implant placement depths on the marginal bone mass at the implants. Meanwhile, we evaluated the peri-implant soft tissue status by measuring the modified plaque index, the gingival index, and probing the depths. The postoperative complications and the patient satisfaction levels were also analyzed. Results: During the 2-year follow-up, the patients' implant retention rate was 100.00%. The implant placement depths did not affect the marginal bone masses at the implants at T0-T1 or T1-T2 (T0: the day after the restoration, T1: at one year after the restoration, T2: at two years after the restoration, all P>0.05). The peri-implant soft tissues in most of the patients were in good condition, and only a few patients had a small amount of plaque or slight gingival swelling. The average probe depth was 3.23±1.20 mm during the follow-up. Only one patient had abutment loosening, and one had a dental prosthesis fall off. The patients did not feel any numbness, continuous pain, or other abnormalities during the follow-up, and the overall patient satisfaction rate was over 97.78%. Conclusion: Locking-taper implants can achieve good clinical outcomes in the restoration of the posterior area with insufficient occlusal-gingival distances. The implants can achieve a high implant retention rate, have no adverse effects on the peri-implant soft tissues, have a low complication rate, cause no significant marginal bone mass loss at the implants, and have a high patient satisfaction rate.

Keywords: Locking-taper implants, insufficient occlusal-gingival distances in the posterior teeth, implant restoration, clinical outcomes

Introduction

With the development of the economy, the improvement in people's quality of life, and the advances in stomatology, there has been a rising awareness among people about oral health care in China. The long-term absence of posterior teeth not only affects eating in patients, but it can also cause tooth deformities, facial asymmetries, and jaw joint abnormalities [1, 2]. In some severe cases, patients can even develop psychological problems and gastrointestinal diseases [3, 4]. Therefore, determining how to effectively treat posterior tooth loss has become one of the main research topics in stomatology [5, 6].

At present, implant treatment is the main method for the restoration of missing teeth. However, due to missing teeth for a long term and to excessive occlusal wear, some patients can have elongations of the opposing teeth, short crowns, or other symptoms related to insufficient occlusal-gingival distances, which can prevent them from undergoing conventional dental implant surgery and which increases the treatment difficulty [7, 8]. Currently, patients with insufficient occlusal-gingival distances are

often treated with orthodontic depression, integrated abutment crown restoration, local osteotomy, or dental extraction in combination with screw-retained implants [9]. However, these methods have some shortcomings, such as limited indications for surgery, post-restoration unsightliness, large surgical trauma, and high dentin hypersensitivity incidence rates [10, 11]. Therefore, it is crucial to explore a more effective and safe method for implant restoration in patients with insufficient occlusal-gingival distances.

So far, studies on locking-taper implants in tooth restoration in patients with insufficient occlusal-gingival distances are few [12]. Thus, we aimed to investigate the effect of locking-taper implants on patients whose occlusal-gingival distances were less than 5 mm. In this simple procedure, the locking-taper implant is placed, and the abutment is installed to make the repair. The dental crown is bonded onto the abutment extraorally, and the crown edge is placed under the patient's gingiva to enhance the patient's occlusal function. We hope this study can provide more data and a theoretical basis for the clinical application of locking-taper implants for patients with insufficient occlusal-gingival distances.

Materials and methods

Participants

In this retrospective study, we analyzed 45 patients (28 males and 17 females) with short occlusal-gingival distances in their posterior teeth area (<5 mm). Since 5-7 mm of occlusal-gingival distance is required for conventional implant restoration, the patients could not undergo conventional implant restorations and instead underwent locking-taper implant restorations in our hospital between September 2018 and October 2019 [13]. A total of 78 locking-taper implants were placed in these patients, and the patients were followed up for two years. The study was approved by the ethics committee of our hospital.

The inclusion criteria were: 1) patients over 18 years old, 2) patients whose occlusal-gingival distances were less than 5 mm in the posterior area, 3) patients who had good compliance and who could carry out normal oral care according to the doctor's instructions, 4) patients who could be followed up in a timely way, 5) patients without mental illnesses or communication problems.

Exclusion criteria: 1) patients with serious systemic diseases, such as heart disease, hypertension, or bone metabolic diseases, 2) patients who were being treated for periodontal disease, 3) patients who could not undergo dental implantation for other reasons.

Methods

Before the operation, the patients underwent routine oral examinations including an examination of their periodontal conditions and oral hygiene. The occlusal-gingival distance in the edentulous area was measured using a periodontal probe. Cone-beam CT was used to measure the three-dimensional bone mass at the implant site.

Before each operation, chlorhexidine (H109-20104, Nanyue Pharmaceutical, China,) was used for oral disinfection followed by 4% articaine hydrochloride (H20060360, Xinning Pharmaceutical, China) for local anesthesia in the patients. A transverse incision was then made at the top of the alveolar ridge in the edentulous area to expose the mucoperiosteal flap, and a pilot drill was used for the positioning and hole drilling. The heights between the mesiodistal parts of the implant and the alveolar bone were distinguished. According to the implant placement depth, the patients were divided into two groups: group A (the implant depth below the bone was over 2 mm) and group B (the implant depth below the bone was less than 2 mm) [14]. After we placed the implants and the silicone caps, we sutured the wounds. Over the three days following each surgery, the patients cleaned the wounds with normal saline and hydrogen peroxide daily to prevent wound infections. Meanwhile, the patients were given antibiotics (H23021066, Baitai Pharmaceutical, China) and dexamethasone (H44024469, Huanan Pharmaceutical, China) for anti-inflammation and detumescence. The patients were also instructed to avoid eating spicy and hot foods and to avoid exercising excessively.

At three months after their implant surgeries, the patients underwent a second operation. The patients underwent the same disinfection

and local anesthesia as described above. An incision was made to remove the silicone cap slowly. A gingival reamer was used to remove the redundant soft tissues on the implant surface and the abutment was installed. After 4 weeks, the healing abutment was taken out and a customized implant-supported prosthesis was fitted to ensure that the crown margin length did not exceed the gingival height after the implantation. The occlusal contact of the prosthesis was adjusted to make sure it was in the right position. Subsequently, the dental crown was fixed and installed to complete the restoration.

The patients were given instructions on oral health care and other precautions and were required to undergo a reexamination once a year in the two years following the restoration.

Outcome measures

Main outcome measures: The patients' implant retentions were evaluated by measuring the bone resorption degrees and by observing if there was any implant loosening, X-ray projections, or the incidence of implant infections or necrosis. The implant retention rate was calculated as the number of successful implants/total number of implants * 100%.

The effects of the different implant placement depths on the marginal bone mass around the patients' implants at different time points after the restoration were observed. The implant bone height referred to the peri-implant bone mass measured using imaging techniques at T0 (on the day after the restoration), T1 (at one year after the restoration), and T2 (at two years after the restoration).

The peri-implant soft tissue status was evaluated by measuring the modified plaque index, the gingival index, and the probing depth. For the modified plaque index, the scores ranged from 0 to 3 as follows: 0 = no plaque; 1 = plaque could be found when the prosthesis surface was gently scratched with a probe tip; 2 = the presence of a moderate amount of plaque; 3 = the presence of a large amount of soft mucinous deposits. The probing depth was defined as the implant placement depth measured using a periodontal probe with 20 g force. The gingival index was divided into four grades: 0 = healthy gingiva, 1 = slight gingival edema, no bleeding when the gingiva was probed, 2 = the presence of gingival edema, and the gingiva bled when probed, 3 = spontaneous bleeding.

Secondary outcome measures: The secondary outcome measures included the incidence of postoperative complications and the patient satisfaction levels.

The postoperative complications included abutment loosening, abutment fractures, cracked porcelain crowns, the prosthesis falling off, pain at the surgical site, and biting discomfort. The complication rate = number of cases of complications/total number of implant * 100%.

The patient treatment satisfaction levels were evaluated in terms of the implant effect aspects, the esthetics, and the incidence of complications. There were three levels: satisfied, almost satisfied, and dissatisfied. Satisfaction rate = sum of the satisfied and almost satisfied cases/total number of patients * 100%.

Statistical analysis

SPSS 20.0 was used for the statistical analysis. The count data are presented as a number or a percentage and were examined using χ^2 tests. The measurement data in a normal distribution are expressed as the mean ± sd and were analyzed using t-tests. $P<0.05$ indicated a statistically significant difference.

Results

Baseline data

In this study, a total of 45 patients were implanted with 78 locking-taper implants. The baseline data are displayed in **Table 1**.

Implant retention rate

During the two-year follow-up period, all 78 implants remained normal, so the implant retention rate was 100%. See **Table 2**.

The effect of the implantation depths on the marginal bone mass at the implants at different time points

The patients were divided into two groups according to their implant placement depths: group A (the implant depth below the bone was

Table 1. Baseline data

Baseline data	Number (Percentage)
Gender	
Male	28 (62.2%)
Female	17 (37.8%)
Age	
20-40	15 (33.3%)
41-60	26 (57.8%)
>60	4 (8.9%)
Periodontal condition	
Good	42 (93.3%)
Poor	3 (6.6%)
Smoking history	
Yes	22 (48.9%)
No	23 (51.1%)
Implant length (mm)	
6	33 (42.3%)
8	45 (57.7%)
Implant diameter (mm)	
5	46 (59.0%)
6	32 (41.0%)
Crown material	
Porcelain bonding to cobalt-chromium alloys	42 (53.8%)
Porcelain	36 (46.2%)

Table 2. Implant retention rate during the follow-up

	Implant	Implant retained	Failure rate	Success rate
T0-T1	78	78	0	100.00%
T1-T2	78	78	0	100.00%

Note: T0: the day after the operations, T1: at one year after the restoration, T2: at two years after the operations.

Table 3. Changes in the marginal bone masses at the implants with different implant placement depths ($\bar{x}$ ±sd)

	Implant (n)	T0-T1	T1-T2
Group A (>2 mm)	34	0.51±0.44	0.13±0.51
Group B (<2 mm)	44	0.43±0.31	-0.05±0.32
t		0.921	1.862
P		0.360	0.067

Note: T0: the day after the operations; T1: at one year after the operation, T2: at two years after the operations. - represents bone mass increase.

over 2 mm) and group B (the implant depth below the bone was less than 2 mm). The two groups showed no intergroup differences in their bone mass changes at T0-T1 or at T1-T2 (both P>0.05). These results show that implant placement depth does not affect the bone mass at the implants at different time points, so it is not a main factor for determining the surgical outcome. See **Table 3**.

Peri-implant soft tissue status after the operations

During the two-year follow-up after the implant restoration, a small amount of plaque was observed in the soft tissues around the implants in the patients (two-year plaque index: 1.45±0.77). No apparent gingival bleeding or severe swelling was observed (gingival index 0.87±0.21), and the average probing depth was 3.23±1.20 mm in the patients. These results suggest that all the patients recovered well and had good oral health and hygiene after the operations. See **Table 4** and **Figure 1**.

Postoperative complications

The incidence of postoperative complications was 2.56%. One patient had abutment loosening, and one had prosthesis fall off. However, the two complications were resolved after repairs were made. No abnormalities were found in the other patients. See **Table 5**.

Patient satisfaction with the treatment

After the operations, the patient satisfaction levels with the implants were evaluated in three aspects: esthetics, comfort, and chewing ability. The overall patient satisfaction rate exceeded 97.78%. See **Table 6**.

Discussion

Having an insufficient occlusal-gingival distance in the posterior teeth area is a common oral disease that can be caused by many factors, such as the long-term absence of the posterior teeth, wearing out the teeth, and a congenital deep bite [15]. Patients with insufficient occlusal-gingival distances usually cannot undergo conventional implant restoration, as the height of the conventional implant prosthesis is usually greater than 5 mm, and the vertical distance

Table 4. Peri-implant soft tissue status after the operations ($\bar{x}\pm sd$)

	Implant	Modified plaque index	Gingival index	Probing depth (mm)
T1	78	1.18±0.55	0.81±0.17	2.65±1.12
T2	78	1.45±0.77	0.87±0.21	3.23±1.20

Note: T1: at one year after the operations, T2: at two years after the operations.

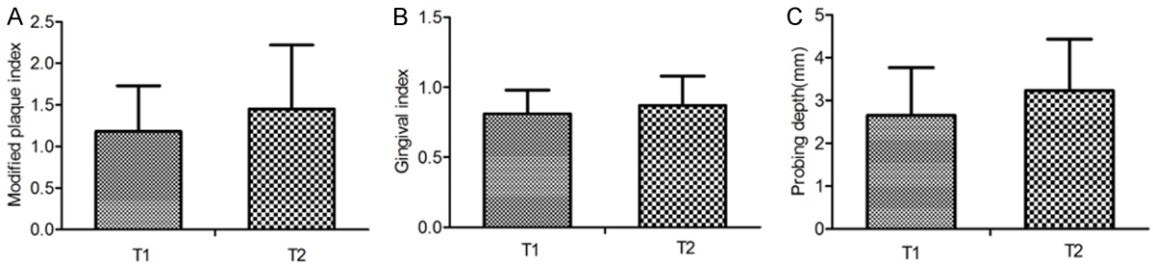

Figure 1. The peri-implant soft tissue statuses at the different time points after the operations. A: Modified plaque index; B: Gingival index; C: Probing depth. T1: at one year after the operations, T2: at two years after the operations.

Table 5. The incidence of postoperative complications (n, %)

Complication	Number	Complication rate
Abutment loosening	1	2/78 (2.56%)
Prosthesis falling off	1	
Pain at the surgical site	0	
Biting discomfort	0	

Table 6. Patient satisfaction levels with the treatment (n, %)

	Satisfied	Basically satisfied	Dissatisfied	Satisfaction rate
Esthetics	22	23	0	100.00%
Chewing ability	30	14	1	97.78%
Comfort	33	11	1	97.78%

between the opposing occlusal surface and the opposing gingiva of these patients is less than 5 mm. Therefore, doctors often need to take other measures for these patients to increase the repair space, and the treatment can lead to a large surgical trauma, a long treatment course, a high risk, a high medical cost, and low patient satisfaction [16].

In this study, we investigated the clinical effect of locking-taper implants in the restoration of the posterior area with insufficient occlusal-gingival distances. Locking-taper implants are a system that can be implanted deeply and that can effectively create a repair space. With locking-taper implants, the implant and abutment can form mechanical fixation by friction and contact pressure, and a central screw as an auxiliary fixation device is not required, which is helpful for the implant restoration of patients with short occlusal-gingival distances [17]. Some studies report that locking-taper implants have excellent mechanical stability. They can effectively reduce the incidence of mechanical damage after a dental implant and can reduce the risk of off-axis stress [18]. In this study, we found that all 78 implants were in a normal condition during the follow-up period, so the 2-year implant retention rate reached 100.00%. These results may also be related to the improvements in both the operations and the implant properties [19]. Our results suggest that locking-taper implants can achieve a good stability and a good success rate in the implant restorations of patients with insufficient occlusal-gingival distances.

Lee et al. reported that the marginal bone mass at the implant is a key factor for the success of implant repair [20]. In this study, we compared the marginal bone mass around the implant with different implant placement depths and found that the marginal bone masses around the implants with different implant placement depths were similar at each time point, indicating that the implant placement depths would not affect the surgical outcome. This finding was consistent with Herrmann et al., who sug-

gested that the stability and long-term effect of the implant restoration are more closely associated with the timing and method of the restoration [21]. Due to the lack of repair space, the conventional implant cannot achieve a good outcome in patients with insufficient occlusal-gingival distances and can lead to incidences of fractured or cracked porcelain and even the prosthesis falling off. In this study, we carried out the locking-taper implant, and in the procedure, we reduced the cusp inclination and balanced the lateral bite force, leading to a low incidence of postoperative complications. Mishra et al. reported that the gap at the interface of the locking-taper implant can be less than 0.5 mm, which can effectively block the entry of bacteria and other microorganisms [22]. The peri-implant soft tissues of the patients in this study were in a good condition and without any noticeable inflammation. The patient satisfaction with the treatment reached 97.78% in this study. The therapy achieved good results in terms of esthetics, chewing ability, and comfort. Topcu et al. also pointed out that the usability, durability, and esthetics of the dental implants are critical factors that patients would consider regarding the treatment [23].

As a retrospective study, there were still some limitations, such as relatively small sample size, a limited follow-up period, and incomplete imaging records. Therefore, more studies with larger sample sizes, longer follow-ups, and complete clinical records need to be carried out in the future for verification.

In conclusion, locking-taper implants can achieve good clinical outcomes in the restoration of posterior areas with insufficient occlusal-gingival distances. The implants can achieve a high implant retention rate, have no adverse effects on the peri-implant soft tissues, have a low complication rate, have no significant marginal bone mass loss at the implants, and have a high patient satisfaction rate.

Disclosure of conflict of interest

None.

Address correspondence to: Haiying Zhang, Department of Stomatology, Jiaozhou Central Hospital of Qingdao, No. 29 Xuzhou Road, Jiaozhou 266000, Shandong Province, China. Tel: +86-0532-87212301; Fax: +86-0532-87212301; E-mail: zhanghaiying_oce@yeah.net

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