

# Effects of Quartz Splint Woven fiber periodontal fixtures on evaluating masticatory efficiency and efficacy

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## Abstract

Masticatory efficiency is altered by mobile teeth resulting from periodontal disease. The goal of our study was to investigate changes before and after fixation of mobile teeth with a Quartz Splint Woven high-strength quartz fiber splint and evaluate the fixation effect.

Forty-two patients with chronic severe periodontal disease and 2 to 3 degree tooth mobility underwent fixation with Quartz Splint Woven quartz fiber splints. Masticatory efficiency was determined before and 1 month after periodontal treatment, and 1 month after fixation. Changes in periodontal probing depth (PD) and periodontal attachment level (AL) were measured and clinical efficacy was evaluated.

Masticatory efficiency significantly increased from 39.32% to 50.95% after treatment ( $P < .001$ ). One month post-fixation, mastication efficiency increased to 67.99% ( $P < .001$ ). At 3 months post-fixation, efficacy was 100% and at 6 months it was 95.24%; PD decreased from  $(4.91 \pm 0.63)$  to  $(4.19 \pm 0.60)$  mm at 1 month post-periodontal treatment, and significantly decreased to  $(3.73 \pm 0.60)$  mm 1 month post-fixation ( $P < .001$ ); AL decreased from  $(4.43 \pm 0.58)$  to  $(3.96 \pm 0.51)$  mm 1 month after periodontal treatment. One month post-fixation, AL reduced to  $(3.64 \pm 0.46)$  mm ( $P < .001$ ).

Masticatory efficiency improved after periodontal treatment. Using Quartz Splint Woven quartz fiber periodontal splint for mobile tooth fixation can further improve mastication efficiency and periodontal condition. A stable and ideal fixation can be achieved within 6 months, which provides a clinical basis for treatment and preserving mobile teeth in severe periodontal disease. Mastication efficiency may be recommended as the index for evaluating curative effects of periodontal disease treatment.

**Abbreviations:** AL = attachment loss, BOP = bleeding on probing, EMP = enamel matrix protein, FGF-2 = fibroblasts growth factor-2, GTR = guided tissue regeneration, PD = probing depth, PDGF = platelet-derived growth factor, PDLSCs = periodontal ligament stem cells.

**Keywords:** loose tooth fixation, masticatory efficiency, periodontal disease, periodontal splint, quartz fiber

## 1. Introduction

Periodontal disease is a chronic, progressive infectious disease that occurs in periodontal tissues. It causes inflammatory destruction of supporting periodontal tissues, causing teeth to

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loosen, shift, and fall out, which seriously affects oral masticatory function. The fixation of loose teeth is necessary in the course of periodontal treatment. The use of periodontal splints for tooth fixation is an effective and important method for treating middle and late stage periodontal disease.<sup>[1]</sup> Quartz Splint Woven is a new kind of high-strength quartz fiber material used to fix loose teeth in periodontal disease. However, does the patient's chewing efficiency change when the material is used to fix the periodontal disease? If there is a change, is it increased or decreased? At present, there is no report on the correlation between the material and chewing efficiency at home and abroad. In this study, Quartz Splint Woven quartz fiber splint was used for loose tooth fixation in periodontal disease, and masticatory and periodontal conditions were compared before and after fixation, and the clinical efficacy of fixation was evaluated.

## 2. Materials and methods

### 2.1. Criteria for patient selection

This study selected adult patients with chronic severe periodontitis admitted in our hospital between December 2014 and June 2017. The following criteria were met for inclusion in the study:

- Periodontitis affected  $>2/3$  of the total teeth.
- Most teeth exhibited a periodontal pocket depth of 4 to 8 mm. The depth of partial teeth was  $>10$  mm, and in these cases, gum

tissue was congested, red and swollen, with bleeding on probing (BOP) positive sites exceeding 90%.

- Attachment loss was >3mm, and at least one anterior or posterior tooth exhibited a degree of mobility reaching 2 or 3, with x-ray evidence of alveolar bone absorption exceeding 1/2 of the root length.

Ultimately, 42 patients with good compliance and the ability to effectively perform periodontal maintenance therapy were selected, including 26 men and 16 women with an age range of 25 to 73 years of age. The total number of teeth exhibiting 2 to 3 degrees of mobility following evaluation was 105 (2 degrees = 74; 3 degrees = 31). Overall, 76 anterior teeth and 29 posterior teeth were evaluated. Included patients received no prior periodontal treatment, had no systemic disease, no masticatory muscle dysfunction, or temporomandibular joint disease. Subjective willingness to retain loose teeth was strong. All patients received repeated oral health education and basic periodontal treatment, and 3 to 4 months periodic periodontal maintenance. The shortest observation period was 8 months, and the longest period was 2 years and 8 months. Twenty-eight cases exceeded 1 year of observation (Fig. 1 and Table 1).

## 2.2. Materials

Teeth were stabilized using Quartz Splint Woven mesh quartz fiber strips and supporting high-flow resin (RTD, France), with 3M full-etching bonding system. Auxiliary materials included polishing brush, polishing paste, bite paper, diamond bur, dental floss, ophthalmology scissors, periodontal probes, small wooden wedges, occlusion papers, photocuring lamps, peeled dry cooked peanuts, sifter, constant temperature drying oven, and a small scale.

## 2.3. Methods

**2.3.1. Basic periodontal treatment.** Patients (Fig. 2A) were treated with a full mouth supragingival scaling operation followed by subgingival scaling and root planing under local anesthesia. Basic periodontal treatment was completed within 1 month and each patient received oral health education. All patients were taught to use Bass brushing until skilled. No antibiotics were used in any patient. One month after periodontal treatment, the patients were treated by fixation of loose teeth (Fig. 2B).

**2.3.2. Quartz Splint Woven silica fiber strips for periodontal splint fixation.** On both sides of the extension of 1 to 2 teeth in the region of severe tooth mobility, floss was used to measure the length of the required fixed dentition. Quartz Splint Woven silica fiber strips were cut to the corresponding length with ophthalmic scissors avoiding light as much as possible. The surface of the teeth designated for fixation were cleaned and polished. A wooden peg was placed in the gap between teeth. Full acid etching was performed in the middle 1/3 of the fixed tooth surface for 1 minute, including adjacent teeth (Fig. 2C). Teeth were thoroughly rinsed for 30 seconds following acid etching (Fig. 2D). Adhesive was applied for 15 seconds between adjacent teeth and adhesive surface, then air was lightly blown across the adhesive surface for 3 seconds, while being treated with light for 20 seconds. When there is a missing tooth in the anterior teeth fixation area, the temporary resin tooth piece can be placed in the edentulous gap, and the resin and the adjacent teeth are first fixed.

Coat high-flow RTD resin was delivered uniformly in the planned fixation area (Fig. 2E), and quartz fiber strips wrapped with high-flow resin were placed in this area (Fig. 2F). The strips were shaped to fit perfectly with the tooth surface, and high-flow resin was again applied on the surface of the fiber strip under isolation of a small shield of the light-curing machine. Meanwhile, the fiber strip was pressed by the device at the mesial and distal gap of each tooth providing tight fixation. Segmented light treatment was applied to each tooth for 5 seconds for initial fixation, then 1 minute following fiber strip application. This process was performed on each tooth for a complete fit and fixation. Lastly, occlusions were adjusted and a final polishing was performed (Fig. 2G).

**2.3.3. Determination of masticatory efficiency.** To determine the efficiency of mastication following fixation, the patients' teeth were brushed and they were given the same brand of peeled dry cooked peanuts (4g) for chewing. The patients chewed the peanuts normally for 30 seconds, the chewed contents spit into a container, and the mouth was fully rinsed of peanut residue, and the rinsed contents were collected in the same container and the container contents sieved (mesh diameter ~2mm). The sieve was repeatedly washed for 60 seconds under the same water flow rate, and the unsieved residue was placed in a drying oven under 50°C constant temperature. Following drying, the masticated contents were accurately weighed with a small balance. After 5 minutes, this process was repeated once and an average was obtained. According to the following formula, masticatory efficiency was determined.

$$\text{Masticatory efficiency} = \frac{\text{total} - \text{residual weight}}{\text{total} \times 100\%}$$

**2.3.4. Periodontal probing depth recording and attachment level.** A 6-point probing method was used to record the periodontal probing depth (PD) and periodontal attachment level (AL) of loose teeth. The 6 points are the mesial, midline and distal at the lip (cheek), and lingual (palatal) side. Depth was measured in millimeters (mm).

## 2.4. Efficacy evaluation criteria

The following criteria were used to determine the level of fixation of patients' teeth following evaluation:

**Well Fixed:** Retained splint did not loosen and remained fixed, no pain was reported (including following percussion testing), chewing function was restored, gums exhibited no obvious redness or swelling, and no teeth were loose.

**Effective Fixed:** There was no loosening of the entire splint, a small part of the resin was collapsed, no overall pain was reported, and some chewing function was restored. There was no obvious redness and swelling of the gums, and the teeth exhibited mobility degree of I. Percussive tapping was abnormal but no obvious pain was reported.

**Invalid fixation:** The entire splint was broken or loosened, with accompanying pain, chewing dysfunction, gingival redness and congestive, obvious tooth looseness, and percussive pain was reported.

## 2.5. Testing

Prior to the periodontal basic treatment (1 month after basic periodontal treatment and 1 month after periodontal splint



Figure 1. Flow chart of this study.

fixation), the PD and AL were recorded by the same experienced physician and the masticatory efficiency was measured. The clinical curative effects were evaluated at 1, 3, and 6 months following tooth fixation.

## 2.6. Statistical analysis

All data were statistically analyzed using SPSS 15.0 statistical software (IBM, Quanzhou, Fujian, China). All data are described as  $\bar{x} \pm s$ . A paired *t* test was used to compare the mean of the same

**Table 1****Clinical data.**

N	Age (mean ± sd)	Gender (M/F)	Loose teeth (II/III degrees)	Number of (frontier/posterior teeth)
42	47.95 ± 11.45	26/16	74/31	76/29

group before and after the treatment.  $P < .05$  was considered statistically significant.

**3. Results****3.1. Self-comparison of masticatory efficiency before and after basic periodontal treatment**

Before basic periodontal treatment, masticatory efficiency ranged from 24.9% to 65.6%, with large individual variation. Masticatory efficiency after basic periodontal treatment also reflected large individual variation, with average masticatory efficiency increasing from 39.32% before periodontal treatment to 50.95% after treatment. Statistical analysis revealed this increase to be significant ( $t = 17.402$ ,  $v = 41$ ,  $P < .001$ ). As such, it appears masticatory efficiency significantly improved after 1 month of periodontal treatment compared with evaluation before treatment (Table 2).

**3.2. Comparison of masticatory efficiency before and after periodontal splint fixation of mobile teeth by high-strength Quartz Splint Woven fiber strips**

After periodontal splint fixation by high-strength quartz fibers strips, masticatory efficiency was also varied greatly among individuals. Still, masticatory efficiency significantly increased from 50.95% after basic periodontal treatment to 67.99% after loose tooth fixation ( $t = 15.067$ ,  $v = 41$ ,  $P < .001$ ), which indicates that 1 month of tooth fixation significantly improves mastication efficiency after periodontal treatment. Prior to periodontal treatment to post-fixation of loose teeth, mastication efficiency significantly increased by 28.67% ( $t = 21.673$ ,  $v = 41$ ,  $P < .001$ ). In light of this evidence, basic periodontal treatment followed by 1 month of dental fixation significantly improved masticatory efficiency compared with the efficiency observed prior to treatment (Table 2).



**Figure 2.** Fixation of mobile teeth. A: Before periodontal treatment, intraoral views, -41/tooth was loosen and shedding, and 42/31/32 teeth exhibited III° mobility; B: intraoral views after periodontal treatment; C: fixation of loose teeth—complete acid etching in the middle 1/3 of the fixed tooth surface including the adjacent gap; D: fixation of loose teeth—thorough rinsing then drying; E: fixation of loose teeth—addition of temporary resin tooth in the missing tooth area. The high-flow resin is coated in the fixed area and adjacent clearance. F: fixation of loose teeth—cut a suitable length of quartz fiber into the area to be fixed; G: fixation of loose teeth—intraoral views of quartz fiber after fixation.



**Table 2**  
**Comparison of masticatory efficiency before and after periodontal treatment and fixation of loose teeth.**

	Masticatory efficiency		Comparison before and after periodontal treatment		Comparison between post-teeth fixation and post-periodontal treatment		Comparison between post-teeth fixation and pre-periodontal treatment	
	Range (%)	$\bar{x} \pm sd$	<i>t</i>	<i>P</i>	<i>t</i>	<i>P</i>	<i>t</i>	<i>P</i>
Pre-periodontal treatment	24.9–65.6	39.32 ± 9.08	17.40	<.001	15.07	<.001	21.67	<.001
Post-periodontal treatment	30.8–77.8	50.95 ± 10.49						
Post-teeth fixation	44.6–90.0	67.99 ± 12.39						

**Table 3**  
**Comparison of periodontal conditions before and after periodontal treatment and after fixation of loose teeth.**

mm	Before periodontal treatment	One month after periodontal treatment	One month after fixation of loose teeth	Comparison between before and after periodontal treatment		Comparison between post-fixation of loose teeth and post-periodontal treatment		Comparison between post-fixation and pre-periodontal treatment	
	$\bar{x} \pm s$	$\bar{x} \pm s$	$\bar{x} \pm s$	<i>t</i>	<i>P</i>	<i>t</i>	<i>P</i>	<i>t</i>	<i>P</i>
PD	4.91 ± 0.63	4.19 ± 0.60	3.73 ± 0.60	16.19	<.001	8.90	<.001	18.45	<.001
AL	4.43 ± 0.58	3.96 ± 0.51	3.64 ± 0.46	13.06	<.001	7.16	<.001	12.17	<.001

AL=attachment loss, PD=probing depth.

**3.3. Changes of PD and AL before and after fixation of high-strength Quartz Splint Woven fiber strips**

One month after basic periodontal treatment, the PD of the teeth significantly decreased from (4.91 ± 0.63) mm before treatment to (4.19 ± 0.60) mm (*P* < .001); AL significantly decreased from (4.43 ± 0.58) mm before treatment to (3.96 ± 0.51) mm (*P* < .001). The PD was (3.73 ± 0.60) mm at 1 month after fixation, which was significantly different than before and 1 month after periodontal treatment (*P* < .001). The AL 1 month after fixation was (3.64 ± 0.46) mm, which was significantly different from before and 1 month after periodontal treatment (*P* < .001) (Table 3).

**3.4. Evaluation of clinical curative effect of high-strength quartz fiber strips at the first, third, and sixth months after fixation of periodontal Quartz Splint Woven splint**

The total effective rate after 3 months of high-strength quartz fiber strips periodontal splint fixation was 100%. After 6 months of fixation, 2 cases failed, with 1 exhibiting severe dentition malocclusion. The dentition crowded the lateral side of the dental arch separated from the fiber splint which may have resulted from a poor fit of the fiber strip to mobile teeth. The other case involved mobility of 4 lower front teeth. Fixation was performed between teeth 34 and 44. The separation of splint and tooth surface occurred at tooth 33 and continued to expand resulting in failure

**Table 4**  
**Clinical efficacy evaluation of the 1st, 3rd, and 6 months after teeth fixation.**

Efficacy	One month after fixation	Three months after fixation	Six months after fixation
Successful (n)	38	34	27
Effective (n)	4	8	13
Failure (n)	0	0	2
Total efficacy rate (%)	100	100	95.24

of fixation. The reason for failure may be due to the fact that the cuspid bears a large occlusal force when occluding laterally with lack of occlusal alignment. After 6 months of fixation, the total effective rate was 95.24% (Table 4).

**3.5. Adverse reactions**

No adverse reactions were observed in any of the patients.

**4. Discussion**

Masticatory efficiency level is indicative of overall chewing function. The amount of functional contact area of the tooth, the supporting tooth structure, the temporomandibular joint, soft tissue in the oral cavity, and the general health of the individual can affect mastication efficiency.<sup>[21]</sup> We selected patients in this study with no differences in functional contact area of the tooth and general health to help ensure the results primarily reflect the relationship between supporting periodontal tissues and masticatory efficiency.

Chronic periodontitis leads to inflammatory absorption and destruction of the alveolar bone, gradual loss of supporting tissues, decreased resistance of periodontal tissue, loosening of teeth, and decreased mastication efficiency. In the present study, mastication efficiency before periodontal treatment was only 39.32%. After standard periodontal treatment, with repeated oral health education, periodontal inflammation was effectively controlled, tooth mobility was reduced, occlusal stability was improved, and mastication efficiency was increased to 50.95%, indicating that canonical periodontal treatment can improve mastication efficiency.

However, tooth mobility caused by severe bone resorption remains difficult to reverse following periodontal treatment. Therefore, effective fixation of loosened teeth, improving occlusive function, and prolonging the period of use of the teeth is important for effective periodontal treatment.

In this study, Quartz Splint Woven high-strength quartz fiber strips were used to fix periodontal splints, and loose teeth were connected with healthy teeth after the control of periodontal

inflammation. This new aggregate chewing structure produced overall movement when the splint is subjected to force, and was transformed from single-toothed competition to multi-teeth cooperation during mastication. This resulted in occlusal force effectively dispersing and the burden sufficiently reduced in the loosened tooth. In addition, when the splint is subjected to a tilted external force due to the change in position of the force fulcrum instead of the single tooth, this allows movement toward the root as a whole, and the periodontal tissue receives more vertical force. The intermittent vertical occlusal force during the chewing process causes traction on most of the periodontal fibers, resulting in effective physiological stimulation and contributes to improved periodontal blood circulation, facilitates repair of damaged periodontal tissue, increases periodontal tolerance, and improves chewing effectiveness.

Quartz Splint Woven high-strength quartz fiber strips, in which the elastic fibers are intertwined in longitude and latitude, demonstrate excellent flexibility and suitable degree of fit with the dental arch. They can effectively buffer occlusal forces and protect the periodontal membrane while effectively fixing abutment teeth. Over time, as the quartz fiber material is subjected to a bite force, the infiltrating composite resin undergoes microcracks and expansion and the unique stability of the quartz fiber strip causes the direction of microcrack stress to be diverted,<sup>[3]</sup> expanding along the interface between the fiber and the matrix. The occlusal force is buffered as closely intertwined reticular fibers prevent matrix microcracks from further merging into fissures that cause fiber breakage. The reticular fibers therefore mimicked periodontal ligament in providing a stress-disrupting action that facilitates repair and regeneration of periodontal tissue. The forced exerted on fixed mobile teeth is cushioned and the periodontal condition is improved.<sup>[4]</sup> The flowable resin can penetrate into the intrafiber of the cross-organized retaining fiber, and the solidified fibers, resins, and teeth become a solid body.<sup>[5]</sup> When the composite resin is fully polymerized, Quartz Splint Woven high-strength quartz fiber strips can significantly increase the resin strength by up to 300%.<sup>[11]</sup> Compared with glass fiber, silica fiber contains crystalline silica, while silica contained in glass fiber is amorphous. As such, silica fiber shows higher resistance to bending and fatigue than glass fiber.<sup>[6]</sup> The quartz fiber splint has decent bending and rigidity, and its flexural strength exceeds 120 MPa. The reinforcing material therein significantly improves splint stiffness.<sup>[7]</sup>

In periodontal disease, alveolar bone is resorbed, bone height is reduced, and the stress on the root increases due to the principle of lever torque. The ability to withstand an oblique load is reduced, and the adaptive capacity of the periodontal tissue is weakened.<sup>[8]</sup> The increased incidence of secondary occlusal trauma leads to decreased mastication efficiency. Previous studies have shown that the average chewing force of the periodontal health population maximally reaches half of the periodontal support, with half of the periodontal support remaining. When alveolar bone absorption of the lower anterior tooth reaches 1/2, the area of the periodontal membrane has been reduced to 33% from 37.54% of the total area of the unabsorbed alveolar bone, and the reserved periodontal capacity has been decompensated.<sup>[9]</sup> Through the objective measurement of stress, it has been confirmed that when the alveolar bone absorbs 1/2 or more of the root length, the periodontal tissue buffering capacity is reduced and the fiber-reinforced composite resin splint fixation can effectively disperse the resultant force to teeth with excess potential.<sup>[8]</sup> The occlusal force is effectively dispersed, which

significantly reduces stress on mobile tooth and reduces periodontal tissue injury. High-strength fiber splints do not interfere with plaque control, which benefits the maintenance of periodontal health,<sup>[10]</sup> reduces biting pain, increases patient comfort,<sup>[11]</sup> and increases chewing efficiency.

Critical clinical operation points: The periodontal splint should exhibit a curved design. The rotary axis of the curved splint is located on the connecting line between the root 1/3 of the abutment teeth at both ends of the splint, which can reduce the oblique displacement of the tooth (cheek, tongue) side, and also tends to increase the axial force and reduce periodontal injury. It is recommended that an increase in number of fixed teeth be pursued to improve dispersion of occlusal force. We emphasize that the tooth surface needs to be thoroughly cleaned and micro-abraded, including the interdental space which requires fixation, in order to eliminate the smear layer and improve the adhesion. In instances of excessive interdental space or crowded dentition and uneven tooth surface, the composite resin can be pre-filled. When shaping the fiber strip, it is recommended to use a suitable device to press the fiber strips into the adjacent gap as much as possible to fit and enhance retention. During operation, mobile teeth should not be pushed or pulled with external force, and the original occlusion relationship maintained. After fixation, material that has the capacity to stimulate the gums should be carefully adjusted and removed as needed. The quartz fiber strips are generally fixed on the labial side so that dental pulp treatment will not be interrupted during fixation.

Periodontal disease leads to loss of periodontal support tissue, preventing further loss of periodontal tissue and restoring periodontal support tissue is the ultimate goal of periodontal treatment. For patients with severe periodontitis, it is particularly important to actively seek new treatment strategies to restore lost periodontal tissue and prevent and delay tooth loss. Periodontal regeneration is an important clinical target for the treatment of advanced periodontal defects in periodontitis. How to effectively promote periodontal tissue regeneration has always been a research hotspot. The first generation of periodontal tissue regeneration has been widely used clinically, that is, on the basis of periodontal basic treatment, periodontal tissue regeneration is achieved by bone grafting, guided tissue regeneration (GTR) and so on. The second generation of periodontal tissue regeneration is in bone grafting, flapping, and GTR, the growth factor is applied to the root surface, and the growth factors bind to the corresponding receptors on the target cells to induce and repair periodontal tissues and promote regeneration. Growth factors that have been used in clinical research are enamel matrix protein (EMP), fibroblasts growth factor-2 (FGF-2), platelet-derived growth factor (platelet-derived growth factor, PDGF), etc.<sup>[12]</sup> Among them, EMP has been used in clinical practice, and Rathe et al<sup>[13]</sup> and other studies have shown that EMP can positively promote the formation of alveolar bone in the treatment of intracapsular defect. Studies by Schmidlin<sup>[14]</sup> have shown that EMP has a certain repairing effect on root surface cement defects caused by periodontal disease. In recent years, studies have found that the combination of b-FGF and GTR has a significant effect on promoting the recovery of alveolar bone height.<sup>[15]</sup>

Third-generation periodontal tissue regeneration involves stem cell therapy, periodontal tissue engineering, and gene therapy. Stem cell-based tissue engineering presents a new therapeutic strategy for periodontal repair. Studies have shown that stem cells from a variety of sources have the ability to form periodontal tissues *in vitro* and in animals.<sup>[16]</sup> Periodontal ligament stem cells (PDLSCs) can regenerate more periodontal tissues compared

with stem cells from other sources.<sup>[17]</sup> Clinical studies have shown that patients were transplanted with autologous PDLSCs and followed up for 3 to 6 years. It was found that PDLSCs regenerated and formed Sharpey fibers and collagen fibers in the site where the periodontal tissues were absent. Imaging showed that alveolar bones were significantly regenerated.<sup>[18]</sup> The application of tissue engineering techniques to periodontal regeneration is a new area of current research. The third generation biomedical materials are used as artificial extracellular matrices to provide scaffolds for tissue regeneration, and together with tissue engineered cells, are made into cellular biomaterial complexes.<sup>[19]</sup> After the complex is implanted into the body, the tissue-engineered cells continue to grow, proliferate, differentiate and secrete the extracellular matrix in the body, gradually assemble and construct into a new tissue or organ, and the scaffold is gradually degraded and absorbed, and finally replaced by the new tissue organ.<sup>[20]</sup> Chitosan-like materials in third-generation biomedical materials can promote periodontal tissue regeneration. The study found that chitosan gelatin sponge implanted in the periodontal defect of experimental animals can promote the growth of new alveolar bone and cementum.<sup>[21]</sup> Liao et al<sup>[22]</sup> showed that a composite scaffold containing chitosan facilitates the proliferation of periodontal ligament cells. In periodontal regeneration therapy, porous scaffolds are critical for blood clot stabilization, wound zoning, cell homing, and cellular nutrient delivery.<sup>[23]</sup> As a natural porous scaffold material, chitosan has the antibacterial activity against the risk of bacterial contamination when the stent is exposed to the oral environment, which may be the best choice for scaffold materials. Periodontal tissue regeneration requires simultaneous repair of different tissues, including cementum, gums, bones, and periodontal ligaments. Varoni et al<sup>[24]</sup> developed a micropattern-based chitosan-based 3-layer porous scaffold that achieves simultaneous healing of multiple tissues driven by periodontal regeneration. Experimental results show that this absorbable 3-layer scaffold is promising as a candidate for periodontal regeneration. Hu et al<sup>[25]</sup> studied the reaction effect of nano-hydroxyapatite coating on porous biphasic calcium phosphate ceramics in the third generation biomedical materials. It was found that the nano-hydroxyapatite coating increased the surface of mesenchymal stem cells on the surface which benefited cell proliferation and osteogenic differentiation. As a scaffold material for periodontal tissue engineering, nano-hydroxyapatite is beneficial to cell adhesion and promotes the proliferative activity of periodontal ligament cells. It is expected to be applied in the field of periodontal regeneration. For periodontal regeneration, gene therapy uses a vector to introduce a specific gene into certain cell types of the periodontal ligament, triggering transcription of these genes, allowing cells to secrete growth factors, and promoting subsequent growth of cementum cells. The differentiation leads to the formation of new attachments.<sup>[26]</sup> An example is the introduction of the PDGF can induce more osteoclast activity. This process has been studied in animal models and has shown that PDGF gene delivery stimulates more nucleated cell activity and improves periodontal regeneration than single-use recombinant PDGF.<sup>[27]</sup> The gene therapy will become a revolutionary therapy in the field of periodontal regeneration.

In summary, this study shows that periodontal disease leads to decreased masticatory efficiency. Standardized periodontal treatment can improve chewing efficiency and improve periodontal status. Application of Quartz Splint Woven high-strength quartz fiber strips for fixation on periodontal splints

of mobile teeth can further increase masticatory efficiency. Ideal fixation and stability can be achieved within 6 months after fixation, which provides a clinical basis for preservation of mobile teeth for severe periodontitis. In evaluating the chewing function of patients with periodontal disease, masticatory efficiency is a simple and fast functional indicator, and is recommended for clinical evaluation of periodontal disease treatment. It is recommended that after 6 to 12 months of fixation, the quartz fiber strips be replaced with a permanently fixed periodontal splint. There are limitations to this study. The observation period was relatively short, therefore, long-term efficacy needs to be further evaluated. In addition, other applications in dental disease need additional exploration. Lastly, maintenance of oral hygiene with extended fixation time remains to be further evaluated. Still, this study provides important insight into the use of the Quartz Splint Woven high-strength quartz fiber strips to reduce tooth mobility, and sets the foundation for future assessments in clinical application of this fixation apparatus.

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