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RESEARCH

Clinical investigation of gingival papilla recession after orthodontic treatment in adults

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Abstract

Objective To investigate the incidence, severity, susceptibility sites of gingival papillary recession (GPR) in adults after orthodontic treatment and the clinical impact of tooth extraction on GPR.

Methods A total of 82 adult patients were recruited and then divided into extraction and non-extraction groups according to whether the orthodontic teeth were extracted (teeth that needed to be extracted when performing orthodontic treatment). The gingival conditions of the two groups of patients before and after treatment were recorded using intraoral photos, and the incidence, severity and predilection sites of GPR after correction were investigated.

Results The results indicated that GPR occurred in 29 patients after correction, with an incidence rate of 35.4%. A total of 1648 gingival papillae were recorded among the 82 patients after correction, of which 67 exhibited atrophy, with an incidence of 4.1%. All occurrences of GPR were classified as papilla presence index 2 (PPI 2) (mild). The condition is most likely to occur in the anterior tooth area, especially in the lower incisor area. The results indicated that the incidence of GPR was substantially higher in the extraction group than in the non-extraction group, with the difference statistically significant.

Conclusion Following orthodontic treatment, adult patients will have a certain proportion of mild GPR, which is more common in the anterior tooth area, especially the lower anterior tooth area.

Keywords Orthodontic treatment · Gingival papilla recession · Tooth extraction · Gingival papilla · Alveolar bone

Abbreviations

GPR Gingival papillary recession
PPI Papilla presence index 2
BOP Bleeding on probing
PLI Plaque index

Introduction

The gingival papilla, also known as the interdental papilla, is conical in shape and fills the wedge space at the root of the contact area between two adjacent teeth, and its lateral margin and apical margin continue from the free gingiva of the adjacent teeth [1]. Gingival recession is a dental disease commonly seen in clinical practice. The clinical symptoms of patients with this disease are mainly gingival pain and alveolar osteoporosis. Gingival recession can be divided into inflammatory gingival recession, mechanical gingival recession, disuse gingival recession, senile gingival recession and early-old gingival recession, according to the pathological mechanism [2]. Following the emergence of gingival papilla recession (GPR), a 'black triangle' will appear in the gap between the two teeth, and this black triangle will affect the appearance in the anterior tooth area [3]. However, gingival recession not only affects the aesthetics of patients' teeth but also causes tooth pain, meaning dentin hypersensitivity will be developed in the case of cold or heat, seriously affecting the patient's daily life. Orthodontic treatment entails a method for the treatment of dental deformity wherein

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pressure is applied to the teeth to promote tooth movement and thus change the tooth arrangement. The MBT™ straight-wire technique is an orthodontic method involving a new generation of straight-wire appliances modified and developed based on traditional straight-wire appliances, with the advantages of low friction, greater stability and allowing the teeth to achieve overall movement, with the correction process using slight continuous force [4]. Following treatment, the upper and lower arches, especially the upper and posterior segments, will be significantly enlarged, the crowding reduced and the alveolar bone remodelled with tooth movement, with good therapeutic results achieved with time extension and correction. The orthodontic treatment process can involve tooth extraction, and it has been demonstrated that this process may lead to inflammation of the gingiva, causing the opening of the TLR4/NF-κB inflammatory signalling pathway [5]. There are various opinions on whether orthodontic treatment will lead to GPR [6–8], with some studies suggesting that this is not the case and that the occurrence of GPR following orthodontic treatment may, in fact, be related to other factors. Other researchers hold the opposite view. While Ciavarella et al. [6] and Beitlitum et al. [7] found that orthodontic treatment is not associated with a reduction in gingival papilla height, another study observed an increased incidence of GPR following correction, which was associated with secondary resorption of the alveolar bone [8].

At present, there exist few studies on the relationship between orthodontic treatment and gingival recession and the related influencing factors, which have not been studied in depth. Therefore, in this study, the incidence, severity, predilection sites and extraction involved in the treatment of GPR among 18–30-year-old adult orthodontic treatment patients are investigated in terms of the clinical impact of GPR. The study provides valuable reference information for the prevention and treatment of gingival recession.

Materials and methods

Research participants

This is a retrospective study involving adult patients who received orthodontic treatment in the Orthodontics Department of Guiyang Stomatological Hospital from 2010 to 2016. The patients were divided into the extraction group and the non-extraction group according to whether or not the orthodontic teeth had been extracted. The incidence, severity and predilection sites of GPR following orthodontic treatment and the clinical impact of tooth extraction on GPR were compared between the two groups. This study complies with the World Medical Association Declaration of Helsinki and was approved by the ethics committee of our hospital. All patients signed an informed consent form.

Inclusion and exclusion criteria

The inclusion criteria were as follows: (1) adult patients receiving orthodontic treatment; (2) patients aged 18–30 years; (3) patients with good periodontal health, as evaluated via plaque index (PLI) and bleeding on probing (BOP) assessments; (4) patients with no gingival recession and interdental gingival papilla filling the adjacent space prior to orthodontic treatment; (5) patients with no obvious abnormal tooth morphology and no missing teeth; (6) the non-extraction group was skeletal Class I malocclusion, mild crowding of the dentition (upper and lower dentition crowding ≤ 2 mm, respectively), and upper central incisor protrusion within the normal range in adult patients; (7) the extraction group was skeletal Class I malocclusion, moderate to severe crowding of the dentition (upper and lower dentition crowding ≥ 9 mm), and adult patients who required extraction of four first premolars; (8) MBT™ brackets were used for correction, and standard orthodontic and periodontal maintenance plans were received during the correction, which achieved normal individual occlusions after correction, upper and lower incisors were upright in the basal bone and the clinical treatment time was < 3 years; and (9) oral photographs were taken at the same magnification using the same professional camera before and after correction in each patient, while photographs were also taken 1 month before bracket installation and 1 month after bracket removal.

The exclusion criteria were as follows: (1) a history of anterior tooth trauma, orthodontic treatment (orthodontic treatment prior to treatment in our hospital) or congenital diseases, such as cleft lip and palate; (2) patients with systemic diseases, such as hypertension or diabetes; and (3) patients with bad habits (e.g. smoking).

Orthodontic treatment methods

Prior to orthodontic treatment, all patients had to be evaluated for oral hygiene and gingival conditions to ensure that they were all healthy. Straight-wire orthodontic treatment was adopted across all the orthodontic procedures. During the treatment process, the following points were given due attention: (1) the molars were directly bound using buccal tubes rather than bands; (2) preliminary alignment of applying fine nickel–titanium archwire was carried out, and stainless-steel round wires were compressed into the scattered front teeth. Oral hygiene education was strengthened, with the patients required to brush their teeth after meals and asked to use the Bass brushing method; (3) the gap was closed using 0.017*0.125-inch stainless-steel square wire in slide mode, with implant anchorage used if

necessary; (4) the Hawley retainer was applied to maintain the correction once completed; and (5) during the orthodontic treatment, periodontal re-evaluation and necessary maintenance treatment were performed every 3 months for 3 years.

Research methods

A total of six photos taken in the mouth of each patient before and after correction were observed by the investigator alone. Here, the intraoral GPR was recorded before and after treatment, and the clinical course of treatment was recorded according to the case data. The papilla presence index (PPI) was used as the main evaluation tool for GPR. Periodontal screening for early detection of periodontal disease (e.g. gingivitis or periodontitis) was adopted to assess the oral hygiene using PLI and BOP evaluations.

Main observation indicators and evaluation criteria

Oral hygiene status

The PLI [9] was used to assess the oral hygiene condition with the following criteria. There was no plaque in the gingival margin; there was thin, barely visible plaque on the gingival surface of the teeth, but the plaque could be scraped with the side of the probe tip; a moderate amount of plaque could be observed at the silver margin or adjacent surface; and there was a great deal of soft fouling in the gingival sulcus or its margin area and adjacent surface.

Gingival condition

The BOP method is regarded as the gold standard for the clinical assessment of gingival inflammation [10]. In this study, the occurrence of gingival inflammation was evaluated based on the presence or absence of bleeding on probing during re-examination. The BOP examination method [11] was performed by placing the tip of the periodontal probe at the bottom of the sulcus and stimulating six sites (mesiobuccal, buccal, distal buccal, mesiolingual, lingual and distal lingual) with a force of around 0.25 N to observe the presence or absence of bleeding, with the BOP scored as 0 or 1 if positive. The evaluation was divided into five grades: (1) the teeth were healthy without inflammation or bleeding; (2) there was inflammatory change in the colour of the gingival without bleeding; (3) there was spotty bleeding after probing; (4) the bleeding was observed to be spreading along the gingival margin; (5) the automatic bleeding of the gums was observed and overflowing the gingival sulcus.

Papilla presence index

In this study, the PPI was used as the main evaluation criterion [12], and the PPI value of each gingival papilla between the upper and lower first molars after correction was recorded. In terms of PPI classification [12], in PPI 1, the gingival papilla fully fills the area between two adjacent teeth, the adjacent gingival papilla is at the same level, there is no GPR and the diagnosis is 'normal'. In PPI 2, the gingival papilla does not fully fill the adjacent surface of the adjacent teeth, but the enamelo-cemental junction of the adjacent surface is not exposed; the gingival papilla and the adjacent gingival papilla are not at the same level, the black triangle has begun to appear and the diagnosis is mild GPR. Meanwhile, in PPI 3, the gingival papilla is retracted further toward the alveolar ridge, the adjacent enamelo-cemental junction is visible, there are a large number of soft-tissue defects, the triangular space is obvious and the diagnosis is moderate GPR. Finally, in PPI 4, the gingival papilla is retracted to below the adjacent enamelo-cemental junction, accompanied by gingival recession on the labiobuccal side, and there is a large soft-tissue defect, with the diagnosis severe GPR.

Severity of gingival papilla recession

In this study, the average PPI of the patients was used to assess the GPR severity. Given that PPI 1 is not classified as GPR, if the patient has no GPR after correction, the average PPI is 1, while if the patient has GPR after correction, the average PPI is > 1.

Self-consistency inspection

The same investigator randomly selected 20 samples at 2-week intervals and again recorded the patient's GPR before and after treatment. The repeatability of the Kappa test indicated good consistency ($K = 0.922$).

Statistical analysis

The data processing was conducted using SPSS 20.0 statistical software, with the measurement data expressed as mean ± standard deviation ($\bar{x} \pm s$) and the counting data expressed as a percentage (%). A t test was used for inter-group comparisons with normal distribution, and a non-parametric test was used for the inter-group comparisons with non-normal distribution. A chi-square test was used to count the data. A P value of < 0.05 was regarded as statistically significant.

Table 1 Basic characteristics of the patients

	Extraction group	Non-extraction group
Gender (male/female)	12/27	15/28
Average age (year)	22.1 ± 3.1	21.6 ± 3.0
Mean course of treatment (month)	28.88 ± 7.35	21.38 ± 7.72
Diagnosis of the patient before the treatment	Skeletal class I misfits	Skeletal class I misfits
Number of tooth extraction	Four first premolars	No
Reasons for tooth extraction treatment	Moderate to severe dentition crowding (crowding degree of upper and lower teeth > 9 mm respectively)	Mild crowding of dentition (crowding of upper and lower teeth < 2 mm respectively) (without tooth extraction)
Diagnosis of the patients after the treatment	The upper and lower incisors were placed upright in the basal bone	The upper and lower incisors were placed upright in the basal bone

Table 2 The incidence of GPR in different tooth positions after orthodontic treatment

Tooth positions	Total of gingival papillae (number)	Gingival papillae retraction (number)	Incidence (%)
Lower central incisors (31/41)	82	17	20.7
Lower lateral incisors (31/32, 41/42)	164	23	14.0
Lower canines (32/33, 42/43)	164	11	6.7
Upper central incisors (31/41)	82	4	4.9
Upper lateral incisors (31/32, 41/42)	164	9	5.5
Upper posterior teeth (35/36)	82	3	3.7

Note: *GPR* gingival papillary recession

Results

General information

A total of 82 patients were enrolled in this study, including 27 males and 55 females, with an average age of 21.9 ± 3.0 years. The patients were divided into the extraction group and the non-extraction group based on whether the first premolar had been extracted. There were 39 cases in the tooth extraction group, 12 males and 27 females, with an average age of 22.1 ± 3.1 years. The average treatment course was 28.88 ± 7.35 months. There were 43 cases in the non-extraction group, 15 males and 28 females, with an average age of 21.6 ± 3.0 years. The average treatment course was 21.38 ± 7.72 months. The gender and age of the two groups of patients were similar, but the treatment course of the extraction group was significantly longer than that of the non-extraction group, and the difference was significant ($t = 5.073$, $P < 0.01$). The results are shown in Table 1.

The incidence of gingival papillary recession in the two groups

The 82 enrolled patients had no GPR before correction, and a total of 29 patients developed GPR after correction, with an incidence rate of 35.4%. A total of 1648 gingival papillae were recorded among the 82 patients after correction, of which 67 gingival papillae were retracted, with an incidence rate of 4.1%. The incidence was the highest in the lower anterior area, followed by the upper anterior area, while gingival recession rarely occurred in the posterior area. The GPR was classified as PPI 2 (mild recession). The incidence of GPR in different tooth positions is shown in Table 2 and Fig. 1.

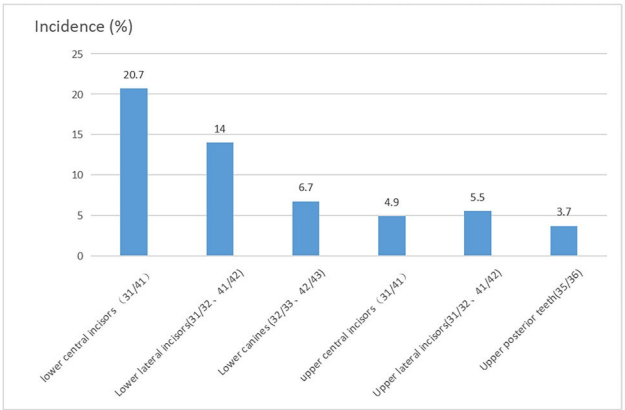

Fig. 1 The incidence of GPR in different tooth positions after orthodontic treatment

Table 3 Comparison of the incidence of GPR after correction between the extraction group and the non-extraction group

Count method	Group	(+)	(−)	Total	X^2	P
According to the number of cases	Extraction group	18	21	39	3.79	0.05*
	Non-extraction group	11	32	43		
According to the number of gingival papillae	Extraction group	51	651	702	32.90	0.000**
	Non-extraction group	16	930	946		

Note: *GPR* gingival papillary recession

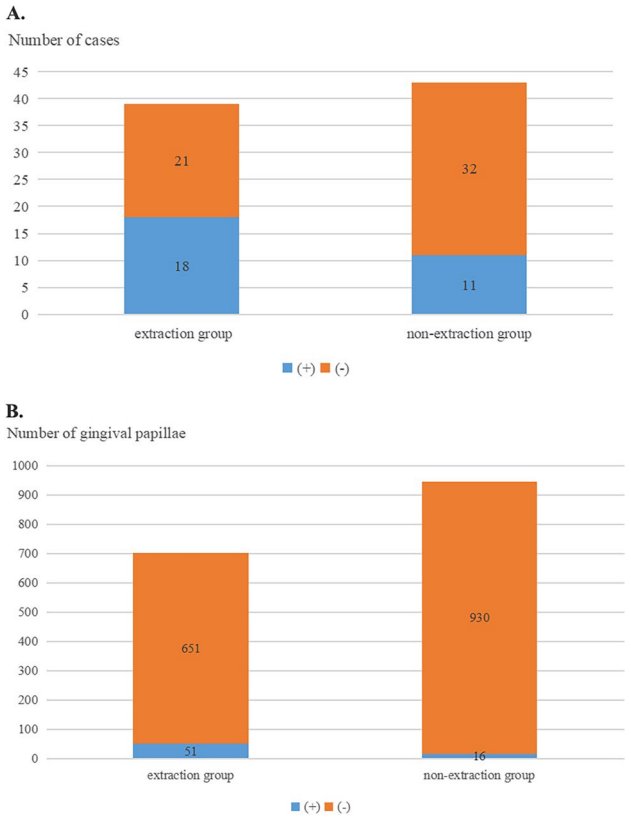

Fig. 2 Comparison of the incidence of GPR after correction between the extraction group and the non-extraction group. **A**. Comparison of the incidence of GPR after correction between the extraction group and the non-extraction group (According to the number of cases); **B**. Comparison of the incidence of GPR after correction between the extraction group and the non-extraction group (According to the number of gingival papillae)

The results indicated that 18 of the 39 patients in the extraction group had GPR and that the incidence rate was 46.2%. In the 702 gingival papillae recorded, a total of 51 were retracted, with an incidence rate of 7.3%. Among the 43 patients in the non-extraction group, 11 had GPR, and the incidence rate was 25.5%. In the 946 gingival papillae recorded, a total of 16 were retracted, with an incidence rate of 1.7%. The statistical results revealed that the incidence of GPR after correction was higher in the extraction group than in the non-extraction group, and there was a statistically significant difference between the two groups ($P < 0.05$), as shown in Table 3, Fig. 2A, B.

Table 4 Comparison of the severity of GPR in the extraction group and the non-extraction group

Group	GPR	t	P
Extraction group	1.0726 ± 0.1044	3.192	0.003*
Non-extraction group	1.0169 ± 0.0329		

Note: *GPR* gingival papillary recession

*Indicates $P < 0.05$

The severity of gingival papillary recession after correction in the two groups

The GPR after correction was classified as PPI 2 (mild recession) in both groups, but the number of gingival papillae involved in the extraction group was higher than that in the non-extraction group. The independent sample t test indicated that the severity of GPR in the extraction group was more serious than that in the non-extraction group. There was a significant statistical difference between the two groups (Table 4).

The predilection sites of gingival papillary recession in the two groups after correction

In the extraction group, 51 gingival papillae were affected following treatment. There were 39 lower anterior teeth: 12 lower central incisors (31/41), 19 lateral incisors (31/32, 41/42) and eight canines (32/33, 42/43); and nine upper anterior teeth: two upper central incisors (11/21), seven lateral incisors (11/12, 21/22) and three posterior teeth (35/36). The incidence in different tooth positions is shown in Table 5.

In the non-extraction group, 16 gingival papillae were affected after correction, all of which occurred in the anterior teeth. There were 12 lower anterior teeth: four lower central incisors (31/41), five lateral incisors (31/32, 41/42) and three canines (32/33, 42/43); and four upper anterior teeth: two upper central incisors (11/21) and two lateral incisors (11/12, 21/22). The incidence in different tooth positions is shown in Table 6. As Tables 5 and 6 show, the

Table 5 The incidence of GPR in different tooth positions after orthodontic treatment in extraction group

Tooth positions	Total of gingival papillae (number)	Gingival papillae retraction (number)	Incidence (%)
Lower central incisors (31/41)	39	12	30.8
Lower lateral incisors (31/32, 41/42)	78	19	24.4
Lower canines (32/33, 42/43)	78	8	10.3
Upper central incisors (31/41)	39	2	5.1
Upper lateral incisors (31/32, 41/42)	78	7	9.0
Upper posterior teeth (35/36)	39	3	7.7

Note: *GPR* gingival papillary recession

Table 6 The incidence of GPR in different tooth positions after orthodontic treatment in non-extraction group

Tooth positions	Total of gingival papillae (number)	Gingival papillae retraction (number)	Incidence (%)
Lower central incisors (31/41)	43	4	9.3
Lower lateral incisors (31/32, 41/42)	86	5	5.8
Lower canines (32/33, 42/43)	86	3	3.5
Upper central incisors (31/41)	43	2	4.7
Upper lateral incisors (31/32, 41/42)	86	2	2.3

Note: *GPR* gingival papillary recession

incidence of GPR in the same tooth position was higher in the extraction group than in the non-extraction group.

Discussion

Gingival recession refers to the movement of the gingival margin toward the root of the enamelo-cemental junction, causing the root of the tooth to be exposed [13]. Glickman et al. [14] reported that gingival recession may or may not be accompanied by periodontal inflammation. One type of gingival recession is GDR. After the loss of height in the gingival papilla, not only can food be easily impacted on the adjacent surface but a black triangle also forms when the papilla retracts 2 mm in the anterior tooth area, thus affecting appearance [15]. There are many classification methods for gingival recession [16], with PPI classification [12] used in this study. This method is used specifically for GPR, wherein the health status of the gingival papilla before and after correction is evaluated. Specifically, GPR is evaluated using intraoral photographs, and the reliability of this method has been confirmed; there is no difference between this method and direct observation and measurement in the mouth, while the repeatability is better [17, 18].

Vasconcelos et al [19]. studied 1825 patients after correction and found that orthodontic treatment can cause gingival recession, but only to a small degree. Elsewhere, Slutzkey et al. [20] analysed 303 patients with gingival recession using multivariate analysis and also reported that the extent and severity of gingival recession are related to orthodontic treatment. In addition, one study evaluated the intraoral photographs after orthodontic treatment in 337 adult patients and observed black triangles in the anterior teeth in 38% of the patients following the treatment [21].

The results of the present study indicated that 35.4% of the 82 patients had GPR after correction, indicating that orthodontic treatment is indeed related to GPR. Only 67 gingival papillae were affected in all 1648 of the observed gingival papillae, with an incidence rate of 4.1%. In the 29 patients with recession, an average of 2.3 gingival papillae were retracted in each case, and the severity was PPI 2. This indicates that the incidence of GPR after correction is not high, and neither is the severity. This result is similar to that obtained by Vasconcelos et al. [19]

The sample in the current study was strictly screened. Prior to orthodontic treatment, the periodontal was healthy and there was no GPR. All patients were young or middle aged (18–30 years old), and the treatment course was under 3 years. Therefore, the physiological recession of gingival papilla caused by poor periodontal health and age-related changes before orthodontic treatment was excluded.

This study found that the incidence of GPR in the upper and lower anterior teeth was 94% (63/67), indicating that GPR is prone to occur in the anterior teeth following orthodontic treatment, after which a black triangle might appear. Moreover, the study found that both the extraction group and the non-extraction group were prone to GPR in the anterior tooth area, with the incidence in the lower anterior teeth the highest. All patients with GPR exhibited crowded upper and lower anterior teeth before

correction. The results obtained by Renkema et al. [22] also indicated that GPR is prone to occur in the mandibular anterior area. The lip-lingual bone ridges of the lower alveolar ridge are thin, and the contact points of the posterior teeth after aligning with the anterior teeth move toward the commissure, away from the crest of the alveolar ridge.

Among the patients in the extraction group, after the lower anterior teeth were aligned, they moved to the far centre, causing alveolar bone absorption. While the regeneration of the alveolar bone occurs after the tooth moves, the bone-regeneration ability of adults is reduced, and the top of the alveolar ridge often moves toward the root. When the distance between the tooth contact point and the crest of the alveolar ridge is > 5 mm, the gingival papillae retract and a black triangle appears [23–25], which will affect the appearance of the anterior teeth.

Overall, GPR was more likely to occur in the extraction group after correction than in the non-extraction group, and the severity was more serious. There exist few studies on the correlation between orthodontic extraction and GPR, either home or abroad. Villard et al. [26] concluded that while their extraction group had a longer treatment course than the non-extraction group, there was no correlation between tooth extraction and gingival recession after correction. However, their research participants were complex and included patients (with GPR) with poor periodontal health prior to orthodontic treatment, while there were numerous interference factors. In the present study, all the patients were adults who did not exhibit GPR prior to treatment, while their bone tissue metabolism had begun to slow and their soft tissues had retracted since the height of the alveolar ridge had decreased. In addition, the treatment course of the patients in the extraction group was significantly longer than that in the non-extraction group, and it was more difficult to maintain oral hygiene, meaning the incidence and severity of GPR increased significantly after the extraction and correction. Other possible reasons for gingival regression include the root–bone relationship, the movement direction at the meso-distal of teeth and buccal-lingual inclination. However, the relationship between these factors and the atrophy of the gingival papilla requires further research.

This study involves several limitations. First, this study did not include a randomised controlled experiment, and there was no blinding method, meaning there was a certain risk of bias. Second, this was a single-centre clinical study, and subsequent multi-centre clinical studies are required for further discussion. Finally, the sample size included in this study was comparatively small, and it is necessary to increase the sample size for further research.

Conclusion

There is a certain proportion of mild GPR in adult patients after orthodontic treatment, with the condition more commonly observed in the anterior tooth area, especially in the lower anterior tooth area. Orthodontic extraction is also one of the risk factors of GPR.

Author contribution Conception and design of the work: LQ; data collection: LQ and XQW; supervision: HW; analysis and interpretation of the data: LS, XQW and LL; statistical analysis: HW and XL; drafting the manuscript: LQ; critical revision of the manuscript: HW and XL; approval of the final manuscript: all authors.

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Data availability All data generated or analyzed during this study are included in this published article

Declarations

Ethics approval and consent to participate This study was conducted in accordance with the Declaration of Helsinki and approved by the ethics committee of Guiyang Hospital of Stomatology. Written informed consent is obtained from all participants.

Consent for publication Not applicable

Competing interests The authors declare no competing interests.

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