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Clinical Trials Study

Influence of pontic design of anterior fixed dental prosthesis on speech: A clinical case study

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Abstract

BACKGROUND

The pontic design of fixed dental prostheses (FDPs) is strongly associated with the phonetic function, and the phonetic function of anterior FDPs with different pontic designs remains understudied.

AIM

To investigate the immediate and short-term influence of pontic design of anterior FDPs on Chinese speech in a clinical case using objective acoustic analysis.

METHODS

Two FDPs with two types of pontic design (saddle pontic and modified ridge lap pontic) were fabricated for one patient with maxillary anterior teeth missing. The acoustic analysis of patient's articulation was conducted immediately after wearing the FDPs and 1 wk after wearing these FDPs.

RESULTS

The effect of FDP on Chinese vowels (/a/, /o/, /e/, /i/, /u/, and /ü/) was insignificant, because the recovery of vowel distortion occurred within 1 wk for both FDPs. Three (/f/, /s/, and /sh/) of eight Chinese fricative consonants were found to have obvious distortions, and the /s/ sound distortion last for more than 1 wk for the patient wearing FDP with modified ridge lap pontic design.

CONCLUSION

The influence of anterior FDP on articulation of Chinese vowels is insignificant, while the articulation of Chinese fricative consonants is more susceptible. When

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fabricating anterior FDPs for patients with speech related professions, saddle pontic design can be an alternative option compared with modified ridge lap pontic design.

Key Words: Fixed dental prostheses; Acoustic analysis; Phonetic function; Pontic design; Clinical case study

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Core Tip: This is the first clinical case study to investigate the effect of two normal types of pontic design of anterior fixed dental prostheses (FDPs) on Chinese speech. Using objective acoustic analysis, we found that the effect of both FDPs on Chinese vowels was insignificant, while the /s/ sound distortion lasted for more than 1 wk for the patient wearing FDP with modified ridge lap pontic design. Therefore, when fabricating anterior FDPs for patients with speech related professions, saddle pontic design can be an alternative option compared with modified ridge lap pontic design.

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INTRODUCTION

Phonetic function is one of the most important factors during prosthodontic treatment. Since maxillary anterior teeth and palate space are a crucial articulation zone for speech production, great attention should be paid to the phonetic issue when dealing with maxillary anterior teeth missing. In specific cases, patients may have anatomical or economic limitations for selecting dental implant treatment, so removable partial denture (RPD) and tooth-supported fixed dental prosthesis (FDPs) are primary alternatives.

It has been well established that RPD can lead to speech distortion[1-4]. Unlike RPDs with different types of clasps and bases, FDPs are more aesthetic and may have less influence on speech. However, it has been known that design parameters of FDP can also lead to speech distortion[5-7]. For instance, Runte *et al*[5] reported that different angulation of maxillary incisors could affect the fricative sound; Julijana *et al* [6] reported that the vestibular-oral diameter of FDPs have influence on the consonant articulation. Therefore, the design of FDPs is strongly associated with the phonetic function, especially when dealing with maxillary anterior teeth missing. In the aesthetic zone, the pontic of anterior FDPs directly contacts with the alveolar ridge, the tongue, and the airflow from the oral cavity during speech production, which may affect speech production. However, the phonetic function of anterior FDPs with different pontic designs remains understudied.

Commonly, anterior FDPs have two main types of pontic designs, which are saddle pontic and modified ridge lap pontic[8]. FDPs with saddle pontic design almost like natural teeth and form a large concave contact with the ridge. Modified ridge lap pontic possesses a nearly convex surface of the ridge, giving the illusion of a tooth. Therefore, patients with these two types of FDPs have different contours of the palate and morphologies of the lingual tooth surfaces, which may generate distinct influence on speech production. Further, it has been known that the recovery of speech distortions caused by dental appliances commonly occur within 3 mo[4,9,10]. However, for patients with speech related professions, the short-term effects of speech distortions caused by FDPs should be also taken into consideration. Therefore, the aim of this clinical case study was to investigate the immediate and short-term influence of pontic design of anterior FDPs on Chinese speech in a clinical case using objective acoustic analysis, which would be beneficial for the clinical settings of phonetic function restoration when dealing with maxillary anterior teeth missing.

MATERIALS AND METHODS

Patient information

A 41-year-old female patient who presented at the department of prosthodontics of the West China Hospital of Stomatology suffered from maxillary anterior teeth missing. The patient has worn an RPD for 4 years (Figure 1), and would like to restore her missing teeth in a fixed way. According to the clinical and radiographic examinations, both the maxillary central incisors and lateral incisors were missing, the labial maxillary bone was relatively thin, and there was an embedder supernumerary tooth in the palatal alveolar bone (cone beam computed tomography images shown in Figure 2).

Treatment

Several treatment options were presented to the patient, including extraction of the supernumerary tooth and the fabrication of implant-supported single crowns, implant-supported FDP, and tooth-supported FDP. The patient preferred to restore the missing teeth in a relatively easy way and selected the option of tooth-supported FDP. In consideration of the patient's small anterior dental arc and two canines with strong roots, six-unit zirconia FDPs (Wieland Dental, Germany) with canines as abutments were determined to be fabricated. After preparation of the abutment teeth, a polyether definitive impression (Impregum Penta; 3M ESPE) was made and poured with Type IV dental gypsum (GC Fujirock EP; GC Europe NV). The cast was digitized with a laboratory scanner (3 Shape D2000; Denmark) and was then analyzed and designed using CAD software (3 Shape Dental System; Denmark). Two types of zirconia FDPs, one with saddle pontic and one with modified ridge lap pontic were fabricated using a CAD-CAM method. Briefly, the framework was milled using zirconia blocks (ZiroX; Wieland Dental) in a CAM system (DWX-52D; Japan). Porcelain (ZiroX; Wieland Dental) was then applied to the labial surfaces of the pontic and a colored glaze (ZiroX; Wieland Dental) was applied to all smooth surfaces of the FDP. Except for the different pontic designs, the design of the rest part of these two FDPs was kept consistent (Figure 3).

Articulation test and procedure

In order to investigate the immediate and short-term effect of pontic design on the Chinese speech, the acoustic analysis of patient's articulation was conducted under the following four conditions: (1) Without wearing any prosthesis (Blank control); (2) Wearing the pristine RPD; (3) Immediately after wearing the FDP with saddle pontic (S-FDP) and the FDP with modified ridge lap pontic (M-FDP); and (4) 1 wk after wearing these two FDPs (S-FDP-1 and M-FDP-1). In order to prevent the bias caused by the interactions of these two FDPs, after wearing the S-FDP for 1 wk, the patient was required to wear the pristine RPD for one additional week before wearing the M-FDP for the next one week.

During acoustic analysis, the FDPs were temporally cemented with dilute zinc polycarboxylate cement (3M ESPE). Six Chinese vowels (/a/, /o/, /e/, /i/, /u/, and /ü/) and eight Chinese voiceless (/f/, /h/, /s/, /sh/, /x/, /z/, /c/, and /r/) fricatives were tested, and five typical and frequently used words for each symbol (Table 1) were selected from a dictionary as a speech stimulus. The patient was asked to sit in an upright position, and the microphone was placed 10 cm away from her mouth. The speech samples were recorded using a high-quality microphone (Shure SM58; Shure Inc, Niles, Ill), which was connected to a Creative Sound Blaster Audigy 6 USB Soundboard (Creative Technology Ltd, Singapore). Recordings were transferred to the computer with a 44.1 kHz sampling rate and 16 bits by Adobe Audition CS6 (Adobe Systems, San Jose, Calif), and approximately 2 s of additional samples were recorded before reading for the purpose of noise reduction. Recorded samples were analyzed by their acoustic characteristics using Praat Software (version 5.4.21; Amsterdam, The Netherlands).

Acoustic analysis

Vowels were analyzed in terms of three formant frequencies (F1, F2, and F3), and linear predictive coding analyses were used to compare the variation among each group. Because upper boundary frequency (UBF) is usually used to describe the vocal characteristic of voiceless fricatives[11-13], eight fricatives were analyzed in terms of UBF. In these cases, voice samples were first converted to wide-band spectrogram, then fast Fourier transformation was used to locate the position of UBF.

Table 1 Chinese phonetic alphabet of the tested vowels and fricative consonants

Chinese phonetic alphabet (Pinyin)					
Vowels					
/a/	/sha/	/fa/	/da/	/ba/	/ya/
/o/	/mo/	/po/	/bo/	/wo/	/huo/
/e/	/he/	/ge/	/se/	/ze/	/ke/
/i/	/bi/	/ji/	/di/	/li/	/pi/
/u/	/tu/	/shu/	/hu/	/zhu/	/pu/
/ü/	/yü/	/jü/	/qü/	/yü/	/lǜ/
Fricative consonants					
/f/	/feng/	/fu/	/fen/	/fang/	/fa/
/h/	/huan/	/hu/	/hui/	/huang/	/huo/
/s/	/si/	/suo/	/song/	/san/	/sen/
/sh/	/shan/	/shuo/	/shan/	/shui/	/shi/
/x/	/xing/	/xiang/	/xu/	/xin/	/xue/
/z/	/zi/	/ze/	/zuan/	/zuo/	/zui/
/c/	/cui/	/cuo/	/ci/	/can/	/cai/
/r/	/rong/	/ren/	/rou/	/ruan/	/ri/

**Figure 1** A patient with maxillary anterior teeth missing has worn a removable partial denture for 4 years.**Figure 2** Cone beam computed tomography images of the patient.**Statistical analysis**

The data were analyzed using the SPSS 21.0 (SPSS Inc, Chicago, Ill) statistics package. Graphs were generated using GraphPad Prism software (version 8.0). One-way analysis of variance (ANOVA) tests with Tukey's multiple comparisons test were

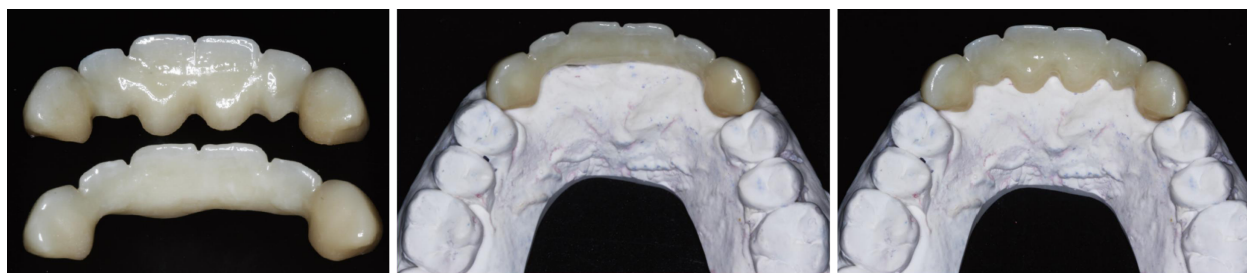


Figure 3 Two removable partial dentures with two types of pontic design (saddle pontic and modified ridge lap pontic).

adopted to evaluate personal changes of each symbol. $P < 0.05$ was considered significant (Ns: Not significant; ^a $P < 0.05$; ^b $P < 0.01$). For the control group used in this study, the articulation of the patient wearing RPD was regarded as a reference for a standard phonetic function, because she had worn the RPD for 4 years and the recovery of major speech distortion was complete.

RESULTS

With regard to the vowels, expect for /u/, the formant frequencies of other vowels (/a/, /o/, /e/, /i/, and /ü/) were at a normal level. As shown in Figure 4, for the /u/ sound, immediately after wearing S-FDP and M-FDP, the F1 frequencies increased and the F3 frequencies had a significant decrease. After 1 wk of adaptation, the F1 and F2 frequencies returned to the normal level.

With regard to the fricatives, three (/f/, /s/, and /sh/) of the eight voiceless fricatives were found to have obvious distortions. As shown in Figure 5, when wearing S-FDP, the UBF of the /f/ sound showed a substantial increase, whereas the UBF of the /f/ sound when wearing M-FDP significantly dropped. After 1 wk of adaptation, both /f/ sound distortions recovered. Further, for /s/ sound, immediately after wearing both S-FDP and M-FDP, the UBFs significantly decreased. After 1 wk, the /s/ sound distortion of S-FDP was back to normal, but the UBFs of M-FDP was still at a lower level (Figure 5). For /sh/ sound, immediately after wearing S-FDP and M-FDP, the patient had a /sh/ distortion, which could recover after 1 wk of wearing both FDPs (S-FDP-1 and M-FDP-1) as shown in Figure 5. For the other five Chinese fricative consonants (/h/, /x/, /z/, /c/, and /r/), there was no significant difference between groups.

Finally, because of less /s/ speech distortion and better tactile impression of the tongue when touching palatal surface of the S-FDP, the patient selected the FDP with saddle pontic design as the permanent prosthesis with RelyX U200 resin cement (3M ESPE).

DISCUSSION

Regarding abutment selection in this case, according to the minimal invasive concept and in consideration of the small anterior dental arc, strong roots of the canines, and normal overlap and overbite, only two canines were selected. However, it should be noted that tipping forces can load on the FDP and abutments upon masticatory movement, and examinations should be carefully conducted to consider whether to include first premolar as additional abutments in the further follow-ups after this clinical trial.

Saddle and modified ridge lap designs were mostly used for anterior FDPs. Saddle pontic replaces all the contours of the missing tooth. Because it overlaps both facial and lingual sides of the ridge lap, this design has long been recognized as being uncleanable and may cause tissue inflammation[8,14]. Then, the modified ridge lap design appeared, which have a slight deflective contour in the lingual surface to prevent food impaction and plaque accumulation[15]. Because of the aesthetics and hygienic feature of the modified ridge lap design, it becomes the most commonly used pontic design in the aesthetic zone for anterior FDPs. However, according to the results of this study, both pontic designs have an immediate and short-term effect on multiple Chinese sounds such as /u/, /f/, /s/, and /sh/. Furthermore, the /s/ sound

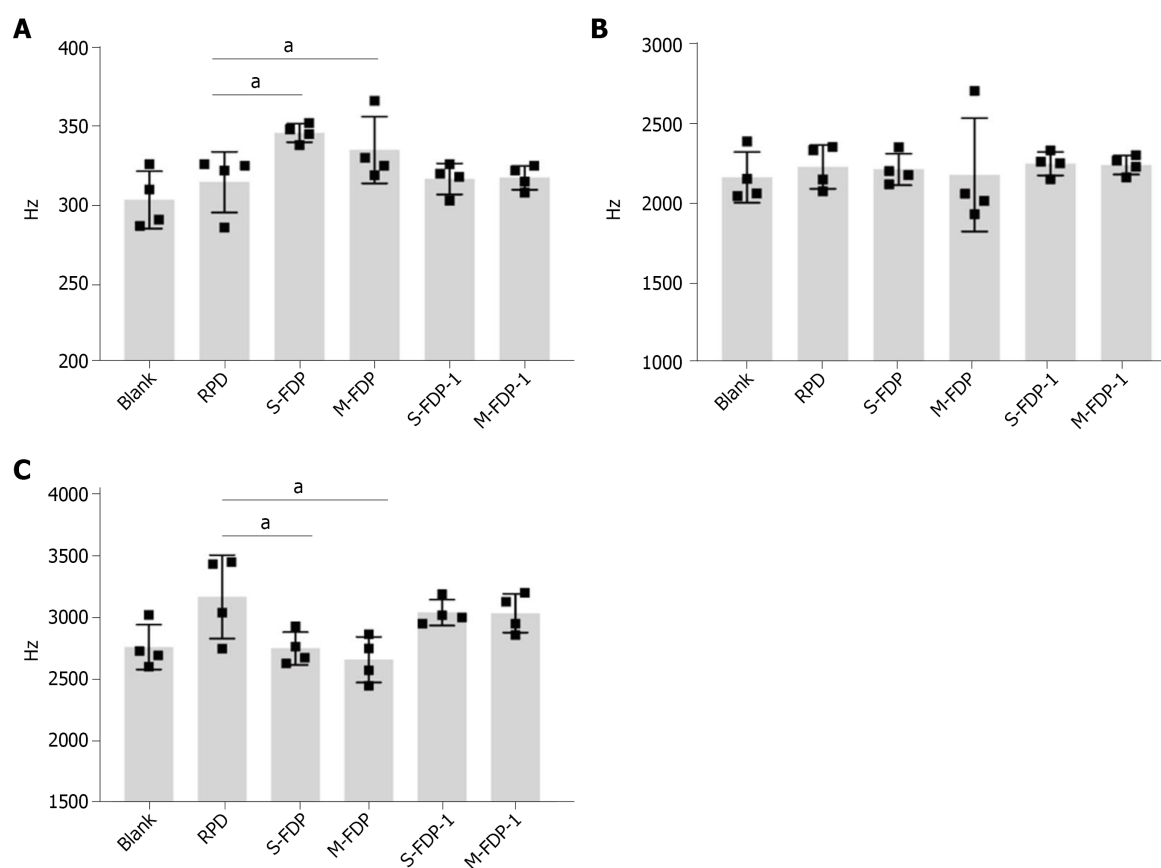


Figure 4 A, B and C frequencies of /u/ sound for blank, removable partial denture, saddle pontic-fixed dental prostheses, modified ridge lap pontic-fixed dental prostheses, S-fixed dental prostheses-1, and M-fixed dental prostheses-1 situation. Data shown are the mean $\pm$ SD, with *P* value deriving from one-way ANOVA tests with Tukey's multiple comparisons test. ^a*P* < 0.05. RPD: Removable partial denture; FDP: Fixed dental prostheses; S-FDP: Saddle pontic-fixed dental prostheses; M-FDP: Modified ridge lap pontic-fixed dental prostheses; S-FDP-1: 1 wk after wearing saddle pontic-fixed dental prostheses; M-FDP-1: 1 wk after wearing modified ridge lap pontic-fixed dental prostheses.

distortion of the patients with M-FDP can last for more than 1 wk. Therefore, attention should be paid to the pontic design when considering phonetic function of anterior FDPs.

Among five Chinese vowels, the /u/ sound demonstrated significant differences when wearing both S-FDP and M-FDP. Because the lingual and labial contours and morphology of crown were changed, features such as tongue position and lip roundness were then affected, resulting in the increase of F1 frequency and the decrease of F3 frequency. Nevertheless, the effect of FDP on other vowels was insignificant, because the recovery of distortion occurred within 1 wk.

The production of consonants is relatively complicated. During the pronunciation of consonants, the airflows in the oral cavity must be modified by different kinds of obstruct and friction, so the morphology and relative positions of the tongue, teeth, and lip are crucial for the consonant production[16,17]. For instance, when producing /s/ sound, the tongue is commonly at a higher position and the maxillary and mandibular incisors should form a narrow space, which can compress the airflow at a high speed[11,18]. In this study, when wearing FDPs, the anterior dental arc, the height of teeth, and the vestibular-oral diameter of pontic were changed, which might be difficult for the patient to accurately attain a right tongue position and narrow teeth space in a short term. Thus, the consonants such as /f/ and /s/ were affected immediately after wearing both S-FDP and M-FDP. However, the consonant distortion recovered within 1 wk for S-FDP, but the articulation of /s/ was still abnormal after wearing M-FDP for 1 wk. Since the modified ridge lap pontic has incomplete contact with the alveolar ridge, there will be a concave space between the lingual surface of teeth and the palate, which may lead to the turbulence when airflows go through the narrow teeth space. Therefore, compared with the saddle pontic design, the modified ridge lap pontic design has a negative effect on phonetic function in a short term.

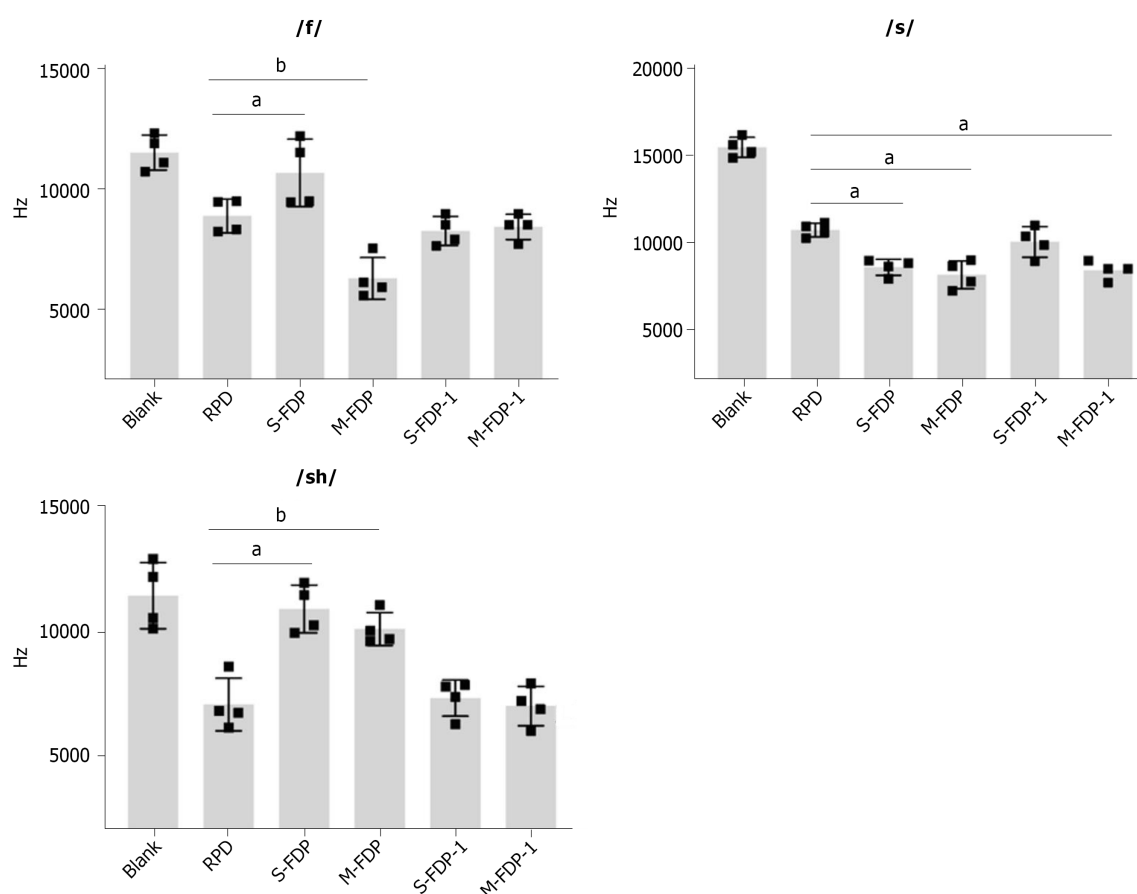


Figure 5 Upper boundary frequency of /f/, /s/, and /sh/ sounds at blank, removable partial denture, saddle pontic-fixed dental prostheses, modified ridge lap pontic-fixed dental prostheses, S-fixed dental prostheses-1, and M-fixed dental prostheses-1 situation. Data shown are the mean $\pm$ SD, with *P* value deriving from one-way ANOVA tests with Tukey's multiple comparisons test. ^a*P* < 0.05; ^b*P* < 0.01. RPD: Removable partial denture; FDP: Fixed dental prostheses; S-FDP: Saddle pontic-fixed dental prostheses; M-FDP: Modified ridge lap pontic-fixed dental prostheses; S-FDP-1: 1 wk after wearing saddle pontic-fixed dental prostheses; M-FDP-1: 1 wk after wearing modified ridge lap pontic-fixed dental prostheses.

Further, phonetic function has been investigated in multiple studies related to different parameters in the anterior region. Bizyaev *et al* [7] reported that two parameters including palatal laminates angulation and anterior wall angulation were important to the phonetic adaption of patients to fixed dentures, and the smaller the difference of these angles, the better the conditions for speech formation. Julijana *et al* [6] found that the vestibular-oral diameter of FDPs have influence on the /s/ articulation. Additionally, angulation of maxillary incisors and maxillary incisal overjet could affect the fricative sounds, but these previous studies were conducted using removable dentures with different incisal parameters [5,13]. Therefore, this study can provide direct evidence and important supplement for the effect of anterior FDP design on the phonetic function. However, this study has a limitation that there was only one patient with a relatively short follow-up period.

CONCLUSION

The influence of anterior FDP on articulation of Chinese vowels is insignificant, while the articulation of Chinese fricative consonants is more susceptible, and most of the speech distortion caused by FDPs recovers within 1 wk. Notably, the /s/ sound distortion lasts for more than 1 wk for patient wearing FDP with modified ridge lap pontic. There, when fabricating anterior FDPs for patients with speech related professions, saddle pontic design can be an alternative option compared with modified ridge lap pontic design.

ARTICLE HIGHLIGHTS

Research background

The pontic design of fixed dental prostheses (FDPs) is strongly associated with the phonetic function.

Research motivation

The phonetic function of anterior FDPs with different pontic designs remains understudied.

Research objectives

To investigate the immediate and short-term influence of pontic design of anterior FDPs on Chinese speech.

Research methods

Two FDPs with saddle pontic and modified ridge lap pontic design were fabricated. The acoustic analysis of patient's articulation was conducted immediately after wearing the FDPs and 1 wk after wearing these FDPs.

Research results

The effect of FDP on Chinese vowels was slight, and the recovery of vowel distortion occurred within 1 wk. Three Chinese fricatives were found to have obvious distortions, and the /s/ sound distortion lasted for more than 1 wk for the patient wearing FDP with modified ridge lap pontic.

Research conclusions

The influence of anterior FDP on articulation of Chinese vowels is insignificant, while the articulation of Chinese fricative consonants is more susceptible to the FDP with modified ridge lap pontic design.

Research perspectives

When fabricating anterior FDPs for patients with speech related professions, saddle pontic design can be an alternative option compared with modified ridge lap pontic design.

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