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Study on the clinical application of digital impression to removable partial dentures

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Abstract

Background: It is well known that intraoral digital impression has been widely used in the field of fixed prosthodontics and achieved good clinical results. Moreover, the clinical application of intraoral digital impression to dental implant and complete denture has also developed rapidly. However, the study on the clinical application of digital impression to removable partial denture is lacking. This study sought to investigate the effects of intraoral digital impression on the clinical adaptation of removable partial dentures (RPDs).

Methods: 78 patients with indications of RPDs were selected. Two RPDs were made for each patient, respectively, with the methods of intraoral digital scanning (the digital group) and taking silicon rubber impression (the traditional group). The clinical adaptation of retainers, major connectors and base plates and the occluding accuracy of RPDs were examined and scored when RPDs were inserted. The scoring results were analyzed by $\chi 2$ test. Mucosa in denture bearing area was reexamined 1 week and 4 weeks after denture insertion.

Results: The retainers' adaptation of RPDs in the digital group was better than that in the traditional group ($P<0.05$). The adaptation of major connectors and base plates of RPDs in two groups was not significantly different($P>0.05$). The occluding accuracy of RPDs in the digital group was better than that in the traditional group, however, the difference was not statistically significant($P>0.05$). Mucosa in denture bearing area was not found abnormal in two follow-up examinations after denture insertion.

Conclusions: The clinical adaptation and the occluding accuracy of RPDs fabricated with the method of intraoral digital impression combined with 3D printing resin model could meet the requirements of clinical application.

Introduction

Intraoral digital impression has been widely used in the field of fixed prosthodontics and achieved good clinical results [1-3]. Moreover, the clinical application of intraoral digital impression to dental implant and complete denture has also developed rapidly [4, 5]. However, very little research has been conducted on the clinical application of digital impression to removable partial dentures (RPDs). The accuracy of the traditional models for fabricating RPDs was affected by the physical and chemical properties of the impression materials and the model materials, practitioner's proficiency in impression technique, the possible wear of the models in the transmission process, etc[6]. To avoid the influence of the above factors on master models, 3shape Trios intraoral digital scanner was used in the present study. Intraoral digital impressions were acquired, and 3D printing resin models of defected dentitions were prepared for fabrication of RPDs for patients selected in this study. The clinical adaptation of retainers, major connectors and base plates and the occluding accuracy of RPDs were evaluated, and accordingly, the feasibility of the clinical application of intraoral digital scanner to RPDs was explored.

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Methods

Equipments and materials

The following equipments and materials were used: intraoral digital scanner (3Shape Trios, 3Shape, Denmark), 3D printer (HDP011903018, Hans Laser, China), 3D printing resin material (Stratasys, USA), cobalt-chromium alloy (BEGO, Germany), artificial resin teeth (HUGE, China), bite registration material (O-Bite, DMG, Germany), silicone rubber impression material (heavy body:Express STD; light body:Imprint II Garant Type 3, 3M, USA), dental stone (Die Stone, Heraeus, Germany).

Clinical data and grouping

78 patients with dentition defect who accepted the treatment of RPDs in department of stomatology, Shanxi Bethune Hospital from January 2016 to December 2021 were selected. There were 39 males and 39 females, aged 45-70 years, with a mean age of 61.1±3.7 years. The cases included in this study were dentition defects of single jaw, specifically, 3 cases with maxillary dentition defect of Kennedy Class I, 23 cases with maxillary dentition defect of Kennedy Class II, 7 cases with mandible dentition defect of Kennedy class II, 13 cases with maxillary dentition defect of Kennedy Class III, 17 cases with mandible dentition defect of Kennedy class III, 9 cases with maxillary dentition defect of Kennedy Class IV and 6 cases with mandible dentition defect of Kennedy class IV. Two RPDs with the same design and the same materials were fabricated by the methods of intraoral digital impression scanning and taking silicon rubber impression, respectively, for every patient included in this study. The RPDs fabricated by intraoral digital impression scanning and 3D printing resin models were recorded as the digital group. The RPDs fabricated by taking silicon rubber impression and making dental stone models were recorded as the traditional group. The experimenter explained the contents of this study to all patients, and all patients participating in the study signed an informed consent form.

Digital master models fabrication

All intraoral digital impressions were taken by the same prosthodontist. Following the operation instructions of 3shape Trios intraoral digital scanner (Figure 1), the scanner was calibrated and the scan head was preheated before scanning the dentition. A dental assistant helped to remove the influence of saliva and oral soft tissue, such as tongue, lip, and buccal mucosa, on scanning. The prosthodontist followed a certain order to scan buccal surface, labial surface, occlusal surface and lingual surface of residual teeth, edentulous alveolar ridge, retromolar pad, and palatal area. Image information irrelevant to fabricating denture was modified and deleted. After upper and lower dentitions were scanned, patients were instructed to bite in intercuspal occlusion (ICO), and buccal images of left and right dentitions in ICO were scanned in turn. The master digital impressions of defected dentitions in ICO were acquired (Figure 2). Data of digital impressions were transmitted to laboratory, and the master models were 3D printed (Figure 3).

Taking selective pressure impression

The selective pressure impression was demanded for the cases of Kennedy Class I and Kennedy Class II. The mandibular dentition defect was taken as an example, and the specific operating procedure was as followed: the image of free end edentulous area was erased on the screen interface of intraoral digital scanner after the defected dentition was scanned. According to the length (from the tooth adjacent to free end edentulous area to the distal border of retromolar pad) and the width (from the buccal to the lingual attached gingiva) of free end alveolar ridge, the wax block was prepared. The wax block was roasted soft and clamped with forceps to place in edentulous area, and then the patient was instructed to bite in ICO. The wax block with occlusion record was taken out of the mouth after it was hardened. The buccal and lingual parts of the wax block with occlusion record squeezed to exceed the mucogingival junction were cut off, and the tissue surface of the wax block was scraped 1mm evenly. Bite registration material was applied to the tissue surface of the wax block with occlusion

Figure 1: *3shape Trios intraoral digital scanner.*

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Figure 2: *Intraoral digital impressions.*

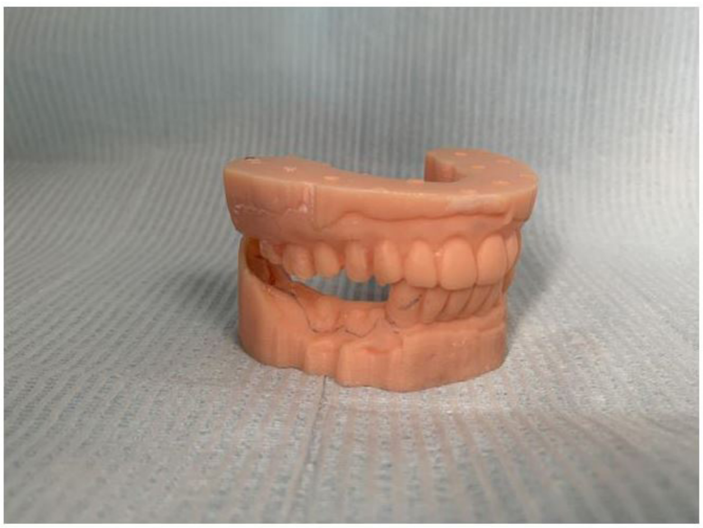

Figure 3: *3D printing resin models.*

record which then was replaced precisely in the mouth. The patient was instructed to bite in ICO and meanwhile made muscle functional trimming with the motions of sucking, blowing, and licking the lingual surface of upper incisors. The wax block with occlusion record was taken out after static bite for 30 seconds, and free end edentulous area was immediately scanned from the adjacent tooth. The marginal line of intraoral digital impression of edentulous area was tagged referring to the mobility and the color of the mucogingival junction of edentulous area, and the stretching range of denture plate was confirmed.

Dental stone models fabrication

After intraoral scanning, the same prosthodontist used silicone rubber material to take impressions for the same patient, and the same dental technician made the dental stones models for fabricating the RPD. The selective pressure impression was taken with the traditional method when the framework was tried and the jaw relation record was transferred at the patient's second visit.

Randomization and blinding method

156 pairs of models were numbered(from No.1 to No.156) by the above experimenter. The same technician followed the clinical designing principles and uesed two groups of refractory models to fabricate RPDs with the same design and the same materials for the same patients. Every pair of RPDs was numbered according to the corresponding models. The self-control method was used to evaluated the clinical indicators when two RPDs were tried in by the above prosthodontist for the same patient. The randomized control method and the random numbers table were used by the experimenter to determine 39 patients wearing RPDs in the digital group and 39 patients wearing RPDs in the traditional group according to the models' numbers after trying in RPDs. Mucosa underneath denture saddles was checked by the prosthodontist 1 week and 4 weeks after denture insertion. The numbers of RPDs were double blind to the prosthodontist and the patients included in this study when RPDs were tried in and reviewed 1 week and 4 weeks after denture insertion.

Evaluation methods

Evaluation methods were developed referring to literature No.8 and No.9 (Table 1). The clinical adaptation of retainers, major connectors and base plates of RPDs and the occluding accuracy were examined, and the results were recorded and scored.

Follow-up examinations after denture insertion

78 patients were reviewed 1 week and 4 weeks after RPDs were inserted. Mucosa in denture bearing area was checked, and it was recorded whether tenderness, redness, swelling or traumatic ulceration existed.

Statistical analysis

The SPSS13.0 software package(SPSS Inc., Chicago, IL, USA) was used for the statistical analysis. $\chi 2$ test was performed on the scoring results of the clinical indicators of RPDs in two groups. $P<0.05$ means was considered

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Table 1: *Evaluation methods when RPDs trying in*

Evaluating indicators	Score	Evaluating criterion
Retainers	0	Retainers were seated smoothly All metal parts of framework fit well with surfaces of teeth Retentive force was moderate
	1	There was resistance, and tissue surface needed a little selective grinding when retainers were seating All metal parts of framework fit well with surfaces of teeth Retentive force was moderate
	2	There was resistance, and tissue surface needed much selective grinding when retainers were seating Retentive force was great, or clasps and proximal plates produce no retentive force when retainers were seated
Major connectors and base plates	0	Dentures were steady and with no warping after they were seated The tissue surfaces of major connectors and base plates fit well with the mucosa
	1	Dentures were with a little warping after they were seated The tissue surfaces of major connectors and base plates fit with the mucosa not well The tissue surfaces needed a little selective grinding
	2	Dentures were with obvious warping after they were seated The tissue surfaces of major connectors and base plates didn't fit with the mucosa Dentures needed to be remade
Occluding accuracy	0	The natural teeth and the artificial teeth had uniform occlusal contact and no premature contact in ICO after dentures were seated Protrusive or laterotrusive occlusion needed a little adjustment
	1	When dentures were seated in ICO, some premature contacting points needed selective grinding Protrusive or laterotrusive occlusion needed some adjustment
	2	The artificial teeth needed much adjustment in ICO and non-central occlusion after dentures were seated

Table 2: *Comparison of the clinical adaptation of retainers between two groups*

Group	n	0	1	2	χ^2	*P*
Digital group	78	69	7	2	6.08	0.048
Traditional group	78	60	11	7		

Table 3: *Comparison of the clinical adaptation of major connectors and base plates between two groups*

Group	n	0	1	2	χ^2	*P*
Digital group	78	75	3	0	1.06	0.601
Traditional group	78	72	6	0		

Table 4: *Comparison of the occluding accuracy between two groups*

Group	n	0	1	2	χ^2	*P*
Digital group	78	67	10	1	2.66	0.270
Traditional group	78	59	17	2		

statistically significant.

Results

Comparison of the clinical adaptation of two groups' RPDs

The retainers of RPDs in the digital group, including the direct retainers and the indirect retainers, adapted to natural teeth better than those in the traditional group($P<0.05$; Table 2). There was no significant difference in the adaptation of the major connectors and the base plates of RPDs to mucosa in the bearing area between two groups($P>0.05$; Table 3). The occluding accuracy of RPDs in the digital group was better than that in the traditional group, however, the difference was not statistically significant($P>0.05$; Table 4).

Status of mucosa

39 patients wearing RPDs in the digital group and 39 patients wearing RPDs in the traditional group were reviewed 1 week and 4 weeks after denture insertion. All patients' mucosa in denture bearing area was checked in two follow-up examinations, and tenderness, redness, swelling and traumatic ulceration were not found.

Discussion

At present, elastomeric impression materials and dental stone are still used to prepare master models for RPDs with casting framework. The clinical adaptation of prosthesis may

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be affected by factors, such as the physical and chemical properties of materials, practitioner's proficiency, indoor environmental conditions, the possible wear of the models in logistics, etc, however, the influences of the above factors on the accuracy of restoration can be avoided by the digital impression method [6]. Many studies had confirmed that the clinical adaptation of fixed prosthesis fabricated on 3D printed resin models by using digital impressions was better than that on the dental stone models [7, 8]. However, the replication accuracy of digital impression for a large range of edentulous alveolar ridge needed to be improved in clinical practice[9]. The working area of impression for removable denture was much larger than that for fixed denture. This study aimed to guarantee the accuracy of digital impression for defected dentition according to the working principle of digital intraoral scanner and the characteristics of taking impression for removable denture, and the following factors that may affect image acquisition effect in the process of taking digital impression needed to be controlled. Firstly, saliva and other body liquids covering soft and hard tissues in oral cavity needed to be aspirated at any time, and especially saliva in mouth floor needed to be controlled when scanning lingual surface of mandible. Due to light reflecting on the liquid surface and formation of blank image, the image of oral tissues was not captured by the scanning head, and the system failed to recognized the morphology of the object, which led to the scanning procedure suspended or data lost. Therefore, the traditional method of taking elastomeric impression was still applied to the cases that saliva in mouth floor could not be controlled. Secondly, the surface of mucosa should be kept moist. The image of oral soft tissue was not captured by the scanning head, and the scanning procedure was suspended if the mucosal surface was overdried. Thirdly, the scanning head should be parallel to the surfaces of the scanned objects and be kept a certain distance when the smooth and shiny surfaces, such as the surfaces of ceramic and metal prosthesis and worn teeth, were scanned. Clinging to the surfaces of the objects should be avoided. Fourthly, the mouth mirror and the saliva ejector were used to appropriately pull and push soft tissues, including lips, tongue, buccal tissue, and mouth floor, to imitate muscle functional trimming when the mucogingival junction area was scanned. The oral frenum and the mucosal area outside the mucogingival junction should be included in the scanning range. The image of the frenum configuration, the light pink attached gingiva and red mucosa was clearly displayed on the screen, the prosthodontist or the dental technician was convenient to modify the impression image. Lastly, data of partial dentition needed to be acquired in most fixed restoration, and the scanning difficulty was low. However, data of soft and hard tissues of the whole dentition relevant to RPDs should be acquired in this study. Therefore, a reasonable order should be followed when scanning, in order to efficiently acquire image data of oral tissues and avoid missing data.

Data of digital impression collected directly from the patient's mouth were stored in the scanner computer and sent to the dental lab via internet. Intraoral data were received and modified if necessary by the technician, and then the master resin models were fabricated in 3D printer. RPDs with bilateral retainers in this study were fabricated with the method of intraoral digital scanning combined with 3D printing resin models, and the clinical evaluation showed that the adaptation of retainers, including clasps, proximal plates and occlusal rests, and the occluding accuracy of RPDs with the digital method were better than those of RPDs fabricated with the traditional method. The possible reasons analysed were as followed: firstly, although the deformation rate of silicon rubber impression material was much less than that of alginate materials, silicon rubber impression still had permanent deformation amount of 0.2% -0.3%. Furthermore, silicon rubber impression could be affected by surrounding factors, such as temperature, disinfectant, etc. Therefore, the accuracy of prosthesis fabricated on the models made of the traditional materials was easy to be affected. However, the way to transfer digital data was not easy to be affected by the above factors[10]. Secondly, the tray bearing impression material was placed into patient's mouth, which could lead to saliva increasing, violent activities of tongue and soft palate, etc. The accuracy of the impression was affected by these factors. Thirdly, Pure expansion phenomenon could happened in the process of dental stone hardening, and the expansion rate was about 0.085%. In addition, the range of crystal particle size of dental stone model was 12-25μm, and the crystal was prismatic or irregular in shape. However, compared to dental stone crystal, the particle of 3D printing resin material was smaller and well-distributed, and the capability of duplicating delicate structure was better. Fourthly, defects in various parts could be produced in the process of making dental stone models, and the risk of wear existed when storing and transferring models. Fifthly, master models were possible to be damaged in the process of fabricating RPDs. Lastly, the stable occlusal record in ICO could be acquired by intraoral digital scanning at the first visit, but the maxillomandibular relationship was recorded at the second visit in the most cases with dentition defect when the traditional method was used. In this study, there was no significant difference in the clinical adaptation of major connectors and base plates of RPDs fabricated with two methods. The reason analyzed could be that the risk of wear or damage to the edentulous alveolar ridge and the palate on the master model was smaller compared to the prominent part of the dentition.

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It was one of the technical difficulties in this study how to take digital selective pressure impression for the dentition with posterior free end edentulous area. The tissue structure of the dentition with posterior free end edentulous area was more complicated than that of with non-free end edentulous area. Under the normal occlusal force, the physiological mobility of healthy natural tooth was about 30μm, and the amount of vertical deformation of the alveolar mucosa in posterior edentulous area was up to 0.14-0.35mm. If RPDs were fabricated by using anatomical impressions, the adverse torsion could happen to the abutment teeth adjacent to free end edentulous area and damage periodontal health of the natural teeth when the free end of RPDs was under occluding force. Meanwhile, when the free end saddle subsided, the stress on the alveolar ridge was not well-distributed, which easily caused rapid absorption of alveolar bone and damaged mucosal tissue in edentulous area. Accordingly, the iatrogenic damage of oral hard and soft tissues and the restorative treatment failure in a short period arose. This study referred to the conventional method of taking selective pressure impression [6], and the method of combining wax block with bite registration material, which was easy for clinically operating, was used. Before intraoral digital scanning, mucosa was pressed for 30 seconds, which imitated functional occlusion in free end edentulous area. Then scanning mucosa in edentulous area should be completed rapidly (within 10 seconds) before mucosal deformation was restored. The experiment results showed that the method of taking digital selective pressure impression was clinically feasible to fabricate RPDs for dentition defect of Kennedy Class I and Kennedy Class II. Because the border of the base plate in edentulous area was hard to determine accurately on the scanner screen, and the method of taking digital selective pressure impression in this study was difficult to implement, the cases with mandible dentition defect of Kennedy class I were not included and discussed in this study.

As mentioned above, when dentition defect was restored with RPDs, compared to the traditional method, intraoral digital scanning and 3D printing resin model could improve the quality of prosthesis. Also, the stable central occlusal relation could be acquired by intraoral digital scanning at patient's first visit, which reduced patient's visiting times, operating steps and the chance of error in prosthodontic treatment[11-13].

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References

1. Ting-Shu S, Jian S. Intraoral digital impression technique: a review. Journal of Prosthodontics. 2015;24(4):313-21.
2. Shimizu S, Shinya A, Kuroda S, Gomi H. The accuracy of the CAD system using intraoral and extraoral scanners for designing of fixed dental prostheses. Dental materials journal. 2017;36(4):402-7.
3. Ting-Shu SU, Sun J, Chen LP. Study of scanning repeatability of intraoral digital impressions. Chinese Journal of Prosthodontics. 2014;15(5):291-6.
4. Kim KR, Seo K-y, Kim S. Conventional open-tray impression versus intraoral digital scan for implant-level complete-arch impression. The Journal of prosthetic dentistry. 2019;122(6):543-9.
5. Sun Y, Sun R, Deng K, Wang Y, Zhou Y. Research and development of digital design and fabrication of complete denture. Zhonghua kou qiang yi xue za zhi= Zhonghua kouqiang yixue zazhi= Chinese journal of stomatology. 2018;53(1):60-5.
6. Endera A, Mehlb A. Full arch scans: conventional versus digital impressions–an in-vitro study Ganzkieferaufnahmen: konventionelle versus digitale Abformtechnik–eine In-vitro-Untersuchung. International journal of computerized dentistry. 2011;14:11-21.
7. Syrek A, Reich G, Ranftl D, Klein C, Cerny B, Brodesser J. Clinical evaluation of all-ceramic crowns fabricated from intraoral digital impressions based on the principle of active wavefront sampling. Journal of dentistry. 2010;38(7):553-9.
8. Sibel C, Babak B, Inès F, Ramin A. Adaptation of zirconia crowns created by conventional versus optical impression: in vitro study. The Journal of Advanced Prosthodontics. 2017;9(3):233-48.
9. Kihara H, Hatakeyama W, Komine F, Takafuji K, Takahashi T, Yokota J, et al. Accuracy and practicality of intraoral scanner in dentistry: A literature review. Journal of prosthodontic research. 2020;64(2):109-13.
10. ang X, Tan J, Li D, Zhou J, Chen L. Clinical evaluation of denture made of pure titanium. Beijing da xue xue bao Yi xue ban= Journal of Peking University Health Sciences. 2010;42(1):60-2.
11. Yuzbasioglu E, Kurt H, Turunc R, Bilir H. Comparison of digital and conventional impression techniques: evaluation of patients' perception, treatment comfort, effectiveness and clinical outcomes. BMC oral health. 2014;14(1):1-7.
12. Park J-S, Lim Y-J, Kim B, Kim M-J, Kwon H-B. Clinical Evaluation of time efficiency and fit accuracy of lithium disilicate single crowns between conventional and digital impression. Materials. 2020;13(23):5467-83.
13. Siqueira R, Galli M, Chen Z, Mendonça G, Meirelles L, Wang H-L, et al. Intraoral scanning reduces procedure time and improves patient comfort in fixed prosthodontics and implant dentistry: A systematic review. Clinical oral investigations. 2021;25(12):6517-31.

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