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New clinical application of digital intraoral scanning technology in occlusal reconstruction: A case report

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Abstract

BACKGROUND

Digital intraoral scanning, although developing rapidly, is rarely used in occlusal reconstruction. To compensate for the technical drawbacks of current occlusal reconstruction techniques, such as time consumption and high technical requirements, digital intraoral scanning can be used in clinics. This report aims to provide a way of selecting the most suitable maxillo-mandibular relationship (MMR) during recovery.

CASE SUMMARY

A 68-year-old man with severely worn posterior teeth underwent occlusal reconstruction with fixed prosthesis using digital intraoral scanning. A series of digital models in different stages of treatment were obtained, subsequently compared, and selected using digital intraoral scanning together with traditional measurements, such as cone beam computed tomography, joint imaging, and clinical examination. Using digital intraoral scanning, the MMR in different stages of treatment was accurately recorded, which provided feasibility for deciding the best occlusal reconstruction treatment, made the treatment process easier, and improved patient satisfaction.

CONCLUSION

This case report highlights the clarity, recordability, repeatability, and selectivity of digital intraoral scanning to replicate and transfer the MMR during occlusal reconstruction, expanding new perspectives for its design, fabrication, and postoperative evaluation.

Key Words: Occlusal reconstruction; Digital intraoral scanning; Maxillo-mandibular relationship; Cone beam computed tomography; Case report

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Core Tip: Selection of the most appropriate maxillo-mandibular relationship and transfer of occlusal information are crucial steps in occlusal reconstruction. The traditional method is complicated, has high technical sensitivity, and may cause the accumulation of errors. In this case, a digital occlusal relation transfer method was established using digital intraoral scanning to improve the accuracy and efficiency of occlusal reconstruction. This method not only prevents the loss of the optimal maxillo-mandibular relationship but also directly transfers the facial morphology of the temporary prosthesis to the final prosthesis, thus achieving a good transfer of aesthetic and functional information. Digital intraoral scanning makes recording the jaw position relationship between the maxilla and mandible, which is the most important but challenging aspect in the treatment process, clear, recordable, reproducible, and selectable.

INTRODUCTION

Occlusal reconstruction refers to all treatment methods that can change the existing abnormal occlusal contact relationship to restore the patient's normal occlusal function[1]. The key to occlusal reconstruction is the use of occlusal pads, mockups, temporary crowns, and other diagnostic temporary restorations, from noninvasive, minimally invasive to invasive procedures, and reversible to irreversible treatments, to verify, adjust, and run in the diagnostic occlusal relationship established in the step by step occlusal design process, and finally obtain the final occlusal relationship of the prosthesis that is most suitable for patients[2,3]. In traditional occlusal reconstruction, acquiring the maxillo-mandibular relationship (MMR) primarily depends on the doctors' experience and patients' subjective feedback and thus lacks an objective

evaluation. In recent years, digital workflow, computer-aided design (CAD), and computer-aided manufacturing (CAM) have become indispensable components of prosthodontics[4]. Digital intraoral scanning is an innovative technology that promotes the development of dental prostheses. Digital intraoral scanning technology uses a small probe, an optical scanning head, to directly obtain the three-dimensional morphology and information of the color and texture of the surface of soft and hard tissues, such as the teeth, gums, and mucosa, in the patient's mouth, to help restore the three-dimensional morphology and color texture of the oral tissues to the greatest extent. Digital intraoral scanning allows the direct transformation of the scanned information of the intraoral dentition to a digital dental model. This method reduces the steps of making impressions and models; avoids the influence of human operation and materials on accuracy; and avoids errors in making, transferring, and pouring plaster models. Compared with traditional methods, digital intraoral scanning technology has the advantages of rapid speed, high precision, and patient comfort. Dentists are increasingly inclined to use digital intraoral scanning instead of traditional impressions[5]. Currently, there are a few reports on the application of digital intraoral scanning technology in occlusal reconstruction. With the help of digital tools, we accurately recorded the MMR in each stage, combined with cone beam computed tomography (CBCT), joint imaging, and clinical examination, to guide clinicians in selecting a comfortable occlusal relationship at any stage for the final reconstruction. These records are intended to provide new ideas for the design of occlusal reconstruction, prosthesis production, and postoperative evaluation of fixed prostheses.

CASE PRESENTATION

Chief complaints

A 68-year-old man visited our hospital for crown restoration because of root canal treatment of the upper right posterior teeth 2 wk previously.

History of present illness

The patient's teeth were worn to varying degrees. One month prior, the patient's upper right posterior teeth developed symptoms of pulpitis due to severe enamel wear and dentin exposure for a long time. He was treated with root canal therapy. He returned to see a dentist for crown restoration.

History of past illness

The patient denied a history of systemic diseases, such as hypertension, coronary heart disease, and diabetes. He reported no history of food or drug allergy, trauma, surgery, or blood transfusion, and his vaccination history was unknown.

Personal and family history

No individual or family history of mental illness was reported.

Physical examination

The patient's facial morphology was left-right symmetrical, the lower 1/3 height of the face was shorter, the jaw space at rest was normal, the degree of opening was normal, the opening type was biased at the initial stage of closure, and there was no clicking or tenderness in either joint. The impact force of the bilateral condyles was large, according to the external auditory canal digital examination. All the teeth were worn to varying degrees, overbite and overjet were normal, and the incisal edge was slightly worn. The enamel of 15-17, 26, 27, 36, 37, and 44-47 was worn in large areas, the mesial lingual tips of 16 and 26 were worn to 1 mm below the gum, and most teeth were probe examined (+/-), cold stimulated (-), and percussed (-). Dental plaque 1°, dental calculus (+), pigment segment (+), and localized gingival congestion and swelling were observed. There were no loose teeth, and the periodontal probing depth was 2-4 mm (Figure 1).

Imaging examinations

Initial temporomandibular joint CBCT: The posterior space of both temporomandibular joints was narrow, the anterior space increased, the upper space increased slightly, and the condyle moved backward and upward (Figure 2A).

CBCT of the temporomandibular joint when wearing the occlusal pad: The anterior space of the joint decreased, the posterior space increased, the upper space slightly increased, and the condyle moved forward and downward. The left joint space was normal, and the right posterior joint space improved compared with when not wearing the occlusal pad (Figure 2B).

CBCT of the temporomandibular joint 1 mo after wearing the temporary crowns: The left joint space was normal, and the right posterior joint space was slightly wider than when wearing the jaw pad (Figure 2C).

CBCT of the temporomandibular joint after bonding the final denture: The left joint space was normal, the right posterior joint space was wider than before, and the bilateral temporomandibular joint space was improved (Figure 2D).

FINAL DIAGNOSIS

Heavy abrasion.

TREATMENT

Preparation before restoration

CBCT was performed before restoration (Figure 2A). Upper and lower alginate impressions were taken, the occlusal relationship was recorded, facial arch was transferred to the articulator, the lifting distance was analyzed and determined, and a dental diagnostic wax-up of 14-17, 24-27, 34-37, and 44-47 was made (Figure 3A), including the occlusal relationship, cusp and fossa relationship, and aesthetic adjustment. Simultaneously, the jaw pad was made according to the same jaw position relationship.

Preparation of the first digital model

The patient wore a maxillary occlusal pad and was instructed to visit once a week (Figure 3B). After wearing an occlusal pad for 3 mo, the patient reported no discomfort, and CBCT of the temporomandibular joint was performed (Figure 2B). At that time, the patient wore an occlusal pad for a digital intraoral scan (Figure 4A).

Fabrication a temporary prosthesis

The occlusal pad was divided into two at the central line for standby (Figure 3C). According to the principle of segmented preparation, tooth preparation was first performed. Referring to the Zhao *et al*[6] method of facial arch transfer to a cross-mounting articulator, the adapted jaw position and vertical distance records determined by the transitional treatment were transferred to the articulator, and temporary restorations for 14-17, 24-27, 34-37, and 44-47 for routine adjustments were made (Figure 5).

Preparation of the second digital model

After using the temporary crowns for 1 mo, CBCT of the temporomandibular joint was performed (Figure 2C). Joints, masticatory muscles, occlusal contact, and periodontal health of the teeth were re-evaluated, and formal restoration after full communication with the patient was commenced. Digital intraoral scanning models were then taken with the temporary crowns (Figure 4B).

Selection of the final occlusal relationship

Before the final restoration was made, the most suitable MMR to meet the requirements of the patient was determined. After completion of the above steps, two occlusal reconstruction models were obtained and retained through digital intraoral scanning (Figure 4). To select the most suitable model for occlusal reconstruction of the patient, comparisons were made using Shape 3D viewer software. With the image of the upper jaw used as the reference coordinate for the comparisons, the models overlapped each other in the same spatial position (Figure 6A). The yellow model was the jaw position

relationship obtained with the occlusal pad, while the blue model was obtained after wearing the temporary crowns. A locally amplified image (Figure 6B) illustrated the difference in the MMR; the anterior edge of the lateral labial margin of the mandibular central incisor was shifted upward and medially by approximately 0.861 mm in the MMR with the temporary crowns compared with that with the occlusal pad. In addition, at the end of the mock-up phase, the occlusal reconstruction vertical distance decreased, overjet decreased slightly, and the patient had a more comfortable bite (Figure 7). Finally, we determined that the occlusal relationship of the second oral scan was most suitable for the final restoration and reconstruction for the patient.

Trying on the final restoration

After removing the temporary crowns, 16 altron all-ceramic crowns were used. In addition, other aspects such as decreased overjet and better condylar position resulted in a more comfortable bite and a pleasing appearance.

OUTCOME AND FOLLOW-UP

Eventually, after wearing the all-ceramic crowns for 2 wk, the patient felt beautiful and comfortable, without obvious discomfort or temporomandibular joint-related symptoms, and underwent CBCT (Figure 2D). At 1 mo follow-up visit, the patient's face shape was normal, the muscle strength of both sides of the maxillofacial region was symmetrical, and the occlusal relationship was excellent during oral examination. The jaw position did not slide during clenching compared with the jaw position during light bite. The patient reported an improved quality of life after treatment. A re-evaluation visit was in 3 mo; if there were no obvious symptoms, the patient could visit yearly.

DISCUSSION

Digital technology of stomatology refers to the technology that helps dentists realize an accurate, efficient, automatic, and intelligent diagnosis and treatment of oral diseases with the help of digital hardware or software. Digital hardware or software includes

but is not limited to intraoral scanning, CBCT, digital diagnosis and design, digital occlusion analysis based on virtual articulators, artificial intelligence, navigation, robotics, and related materials. Dental CAD and CAM are typical applications of digital stomatology. The process includes digital impression, denture CAD, and CAM[7]. In traditional occlusal reconstruction, the acquisition of jaw position relationship largely depends on the doctors' experience and patients' subjective feedback, and therefore lacks an objective evaluation. Digital tools enable an objective evaluation of the treatment to help verify whether the reconstructed occlusion is coordinated with the functional state of the oral and maxillofacial system. The application of digital technology can help simulate and predict the effect of reconstructed occlusion and the accuracy of replication and transfer of occlusal relationships before invasive procedures. Treatment that was originally highly dependent on clinical experience has become procedural and reproducible with digitalization, and the technical threshold for doctors is relatively low. Digitalization can help achieve personalized medical treatment that conforms to patients' anatomical and physiological states and improve the pathological state, patient satisfaction with treatment, and quality and efficiency of communication between doctors and patients and between doctors and technicians. Digitalization in prosthodontics has been widely accepted by peers and is regarded as an irreversible trend. There is also consensus to build a complete process of digital prosthodontics—digital diagnosis, digital designing, digital manufacturing, and digital treatment"[8,9].

When the patient adapts to the new occlusal relationship formed using the occlusal pad and has no obvious subjective discomfort, objective assessment is performed by palpation with both hands to check the strength of contraction of the temporal muscle and CBCT to check whether the condylar position is normal. Then, the occlusal pad is debugged, and the first digital intraoral scanning is performed to collect the digital information of the MMR, to obtain the first type of occlusal relationship. After a certain period of temporary crown treatment with varying degrees of adjustment, running-in diagnosis, and verification, depending on the adaptability of patients, digital intraoral scanning is used once again to acquire another type of occlusal relationship.

In the widely used traditional method, the key to achieving occlusal reconstruction lies in the clinical experience of doctors to guarantee the accuracy of MMR in the entire process of copying, transferring from the occlusal pad to the temporary crowns, and making the final restorations. Moreover, with the restriction of its mock-up stage, the MMR available is, simply, the one acquired in the final coronal phase and is, therefore, comparatively limited. In this case report, digital intraoral scanning accurately recorded a series of digital information of the MMR during occlusal pad commissioning and temporary crown wearing. These data can help us find the best position for occlusal reconstruction, thus minimizing the errors generated in the tedious process of recording the best MMR relationship.

In traditional occlusal reconstruction, adaptive grinding of diagnostic temporary restorations, such as occlusal pads and temporary crowns, has advantages and disadvantages. Adjusting the occlusal relationship in the horizontal direction can better reduce the overbite of the anterior teeth, which is conducive to the condyle sliding upward and forward to achieve a satisfying central position relationship. The vertical distance will decrease due to wear, thus reducing the increased vertical distance in the process of occlusal reconstruction. Digital intraoral scanning technology can not only prevent the loss of optimal jaw relationship caused by various errors in the occlusal pad commissioning stage and temporary crown fabrication and grinding process but also provide a chance to choose the appropriate MMR in the clinic. The application of digital intraoral scanning in the occlusal reconstruction of fixed prosthesis makes recording the jaw position relationship between the maxilla and mandible, which is the most essential but fuzzy aspect in the treatment process, clear, recordable, reproducible, and selectable.

We can select either the occlusal relationship of the first oral scan (Figure 4A) or the second (Figure 4B) for the final reconstruction. In the digital software system, at the end of the mock-up phase, compared to when wearing the occlusal pad, the most anterior end of the lateral labial margin of the mandibular central incisor was shifted upward and medially by approximately 0.861 mm. Compared with digitally recorded

information on the occlusal relationship between the end of the temporary crown and the end of the occlusal pad wearing, the occlusal reconstruction vertical distance decreased, and the overjet decreased slightly. There were supernumerary teeth between the maxillary central incisors of this patient; however, he refused extraction of the supernumerary teeth and restoration of the occlusal relationship in the anterior tooth area. The occlusal relationship of the temporary crown stage, with a slightly smaller overjet, was used for posterior teeth occlusal reconstruction, which helped retain the guiding function of the anterior teeth to a greater extent and was more conducive to the comfort of the patient's temporomandibular joint. By comparing the occlusal relationship of the patient's two oral scans, we determined that the occlusal relationship of the second oral scan was most suitable for the final restoration and reconstruction. Digital intraoral scanning has two advantages in occlusal reconstruction: (1) The occlusal relationship can be accurately reproduced and transferred stepwise from the occlusal pad to the temporary crown to the final restoration; and (2) It can establish a perfect occlusion that includes correct lateral occlusal guidance, uniform contact during centric occlusion, and a reasonable opening angle during non-centric motion.

In addition, the final occlusal relationship replication and transfer of diagnostic temporary restorations in traditional full-mouth occlusal reconstruction often use cross-mounting articulators. The traditional steps in this method include taking multiple impressions, pouring models, and recording multiple occlusions. Each step has potential for errors, and they cannot be quantified. These complex steps and potential errors can affect the occlusal accuracy of the final prosthesis and often requires considerable time to adjust in the clinic[10-12]. Digital intraoral scanning can minimize these errors and simplify the process. Digital intraoral scanning allows the direct transformation of the scanned information of the intraoral dentition to a digital dental model, three-dimensional prediction of the repair effect, and transfer the treatment design to the final prosthesis through digital design and production technology to enable the "what you see is what you get" treatment effect[13,14]. Using digital dental scanning equipment, the morphology of temporary restorations after functional

adaptive wear, occlusal contact relationship, and refined abutment preparation can be recorded and the digital model established and matched. Digital intraoral scanning has become an important dental operation technology. Based on the data obtained, crown restoration and the production of implant superstructures, orthodontic devices, removable partial denture brackets, and other structures, are carried out[15-19]. The rigidity of the digital model can avoid transmission errors caused by the variety of mandibular movements and the errors while making occlusal records in the restoration process. It can also shorten the clinical operation time and steps while improving accuracy[20]. Treatment costs are expected to decline with the continuous development of digital technology. We believe that intraoral scanning will become popular in the next few years[21].

Owing to the close relationship between digitalization and artificial intelligence (AI), it is believed that with the rapid development of AI technology in the future, the application of digitalization technology in clinical practice will become increasingly more common and operation will become increasingly simple and standardized; this in turn will provide a strong support for the development of AI medicine.

CBCT has been widely used in various fields of stomatology, including orthodontic three-dimensional cephalometry, orthodontic treatment plan design, implant surgery planning and guide plate design, maxillofacial surgery diagnosis and surgery design, maxillofacial surgery navigation implementation and guide plate design, temporomandibular joint diagnosis, periodontal diagnosis, root canal apical morphology and root fracture diagnosis, sleep apnea syndrome, and soft palate and pharyngeal morphology diagnosis. It is the most widely used and promising digital technology in stomatology. In addition to routine clinical examination, the examination methods in the occlusal reconstruction process of the fixed prosthesis also include the use of imaging to evaluate the structural changes of the oral and maxillofacial system, evaluate the motor functions of the oral and maxillofacial system, detect bruits of the temporomandibular joint, and examine the electrophysiological function of the masticatory muscles[22,23]. In this case, CBCT was used for occlusal reconstruction in a

patient with severe abrasion. By a combination of the clinical symptoms of the patient before repair and 1 mo after permanent repair and the morphological changes of the temporomandibular joint space and condylar position shown by CBCT, the clinical treatment effect of fixed denture occlusal reconstruction was objectively evaluated Researchers believe that long-term dentition loss or serious wear leads to reduction in the vertical distance, and the condyle then shifts backward[24]. Consistent with the results of previous studies, in this patient, CBCT showed that the anterior space of the TMJ was significantly larger than the posterior space before occlusal reconstruction and that the condyle was displaced posteriorly. After digital intraoral scan-assisted occlusal reconstruction, CBCT showed that the left joint space was normal, the right posterior joint space was wider than before, and the space of the bilateral temporomandibular space was better. The patient's temporomandibular joint had not undergone pathological changes; therefore, only the jaw position and movement adapted to the physiological state of the joint muscles needed to be determined by digital equipment. Using this case as a reference, restoration with an accurate occlusal relationship can be achieved.

CONCLUSION

This clinical report showed that the application of digital intraoral scanning for occlusal reconstruction of a fixed prosthesis can accurately record the occlusal relationship of jaw position in different stages to avoid the loss of an optimal jaw relationship. Digital intraoral scanning makes recording the jaw position relationship between the maxilla and mandible, which is the most important but challenging aspect in the treatment process, clear, recordable, reproducible, and selectable. We hope that this clinical report will provide a new clinical reference for the design, fabrication, and postoperative evaluation of occlusal reconstruction of fixed prostheses. These conclusions should be verified with the treatment of more patients in the future.

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