A non-physiological occlusal plane caused by continuous tooth loss, occlusal wear, and failure of a prosthesis may result in an unattractive appearance and functional problems, such as reduced masticatory efficiency and occlusal interference. Therefore, when undertaking prosthetic treatment for edentulous patients or patients with a collapsed occlusal plane, it is important to establish an occlusal plane that is compatible with masticatory function. The patient in this case report had undergone restoration of a completely edentulous maxilla using an implant-supported fixed prosthesis. On follow-up examination in the following 6 years, mechanical complications were observed in the existing implant prosthesis, including porcelain chipping, occlusal wear, and screw loosening. Moreover, due to occlusal wear and supraeruption of the opposing anterior teeth, as well as loss of some posterior teeth, the occlusal plane had collapsed. Following diagnosis, the patient underwent full mouth rehabilitation, involving additional implant installation in edentulous sites, recreation of the existing prosthesis, and prosthetic restoration of all remaining teeth. (J Korean Acad Prosthodont 2018;56:141-53)

Keywords: Occlusal plane; Full mouth rehabilitation; Anterior guidance

Introduction

The mechanical complications are common in prosthetic rehabilitation involving implant-supported prostheses. The main mechanical complications related with implant-supported prostheses, which can lead to the need for repairs or failures, are screw loosening, screw fracture, fracture of the metallic or porcelain structure, and occlusal overload. Design characteristics of the prostheses and implants, the materials employed and biomechanical issues all exert an important influence on the results of these prostheses.1

In order to achieve successful prosthetic rehabilitation in a patient with complete edentulism or a collapsed occlusal plane, the occlusal curvature and occlusion should be in harmony with the functional movements of the mandible.2 The anterior teeth are considered the anterior controlling factors and the temporomandibular joints (TMJs) are considered the posterior controlling factors. The posterior teeth are positioned between these two controlling factors and thus can be influenced by both to varying degrees.3

During an eccentric movement, the nonworking side condyle moves downward, forward, and inward in the mandibular fossa around axes positioned in the rotating condyle.4,5 Dawson4 emphasized that the medial pole stop and the lateral ligaments of the condyle prevent the mandibular posterior teeth from moving horizontally toward the midline, an essential anatomic design that makes a normal occlusal curvature possible. Occlusal conditions affect the course of condylar remodeling and lead to noticeable changes in the shape of the joints, and occlusal disharmonies are responsible for condylar displacement; these, in turn, may be the reason for the typical reshap-
The loss of anterior guidance for posterior disclusion can lead to deflective occlusal contact, and pathologic occlusal wear occurs as a result of hyperactivity of the elevator muscles and horizontal overload. In a patient with a collapsed occlusal plane caused by pathologic occlusal wear, reconstruction of occlusion could be achieved by establishment of an occlusal plane in harmony with the horizontal envelope of function and distribution of the load to the maximum number of equal-intensity tooth contacts during intercuspation. Also, anterior guidance should be determined for immediate disclusion of all posterior teeth, eliminating any potential overload in eccentric movements and reducing muscle loading of the joints and the anterior teeth.

This clinical report describes the re-establishment of a collapsed occlusal plane in a patient who experienced a complicated outcome after prosthetic rehabilitation involving implants.

Case report

A 74-year-old patient visited with a chief complaint of difficulty in chewing food because of excessive occlusal wear of a previously restored prosthesis 6 years earlier. According to the patient’s past dental history in the Department of Prosthodontics of Gangneung-Wonju National University Dental Hospital, 6 years earlier the patient had presented with an edentulous maxilla and loss of several mandibular molars (Fig. 1). The remaining teeth were worn, and showed a reverse curve of Wilson and curve of Spee. Following diagnostic procedures, the missing teeth were rehabilitated by installation of implants, and prosthetic treatment was performed on the worn teeth, except for the worn mandibular anterior teeth (Fig. 2). However, on follow-up examination in the following 6 years, the implant-supported fixed prosthesis showed frequent screw loosening, and occlusal overload caused root fracture of the mandibular left first molar and right first premolar (Fig. 3).

Intraoral examination revealed loss of some mandibular posterior

Fig. 1. Intraoral examination in 6 years ago. (A) Maxillary occlusal view, (B) Right lateral view, (C) Frontal view, (D) Left lateral view, (E) Mandibular occlusal view.
Fig. 2. Prosthetic rehabilitation in 6 years ago. (A) Maxillary occlusal view, (B) Right lateral view, (C) Frontal view, (D) Left lateral view, (E) Mandibular occlusal view.

Fig. 3. (A) Horizontal root fracture of the mandibular right first premolar, (B) Vertical root fracture of the mandibular left first molar.
teeth, generalized occlusal wear of the remaining mandibular teeth as well as the implant prosthesis, and porcelain chipping of the implant prosthesis (Fig. 4). Radiographic examination revealed that the peri-implant marginal bone level was maintained without noticeable bone loss, but there was a misfit between the abutment and the prosthesis (Fig. 5). The patient showed hypertrophy of the masseter muscle under strong tension and a slightly lower gonial angle (118°) when compared with the normal value (130°) on lateral cephalometric radiographic examination, which indicated the higher maximum bite force (Fig. 6A). The transcranial radiograph was taken to determine whether a temporomandibular joint disorders existed. The left mandibular condyle was more mobile than the right, but no specific pathologic bony change was found (Fig. 6B).

The analysis of loss of the occlusal vertical dimension (OVD) was performed considering interocclusal rest space, phonetics, facial appearance, history of occlusal wear, and loss of posterior support. The patient’s interocclusal rest space between the chin tip and nose tip was measured to be 3 mm, and was similar to the normal value of 2 - 4 mm. On evaluation of the “s” sound, the distance between the lingual surface of the maxillary incisors and the incisal edge of the mandibular incisors was about 1 mm, and therefore normal. There were no signs of loss of OVD in the facial appearance and the facial height ratio was within normal range according to the Willis method and the McGee method (Fig. 7). According to these evaluations, it was concluded that the patient had probably no or minimal loss of OVD.

For accurate diagnosis and fabrication of a provisional restoration, a face-bow transfer was performed to mount the diagnostic cast on a semi-adjustable articulator (KaVo Protrar Evo 7, KaVo Dental GmbH, Biberach, Germany) by using an interocclusal record made using an anterior programming device (Lucia jig) and silicone bite registration material (Futar D, Kettenbach GmbH & Co. KG, Eschenburg, Germany) (Fig. 8). Diagnostic cast analysis showed the anterior guidance could not disocclude the posterior teeth during eccentric
movement. The left mandibular second premolar and molars were missing, and the existing implant prosthesis showed a reversed curve of Wilson and curve of Spee due to excessive occlusal wear (Fig. 9). In addition to these problems, analysis of the occlusal plane by using various landmarks such as Frankfort horizontal plane (Fig. 6A), the commissure line of the mouth, hamular notch-incisive papilla plane, and retromolar pad, showed faulty orientation and a collapsed occlusal plane (Fig. 10). These findings led to a diagnosis of posterior bite collapse with an uneven occlusal plane.

Accordingly, the treatment goal was to establish anterior guidance...
providing posterior disclusion and restore the occlusal plane through the correction of curve of Wilson and curve of Spee. Full mouth rehabilitation was planned with additional implant installation for restoring the missing teeth and cross-arch splinting of the maxillary anterior implant prosthesis. To restore posterior occlusal support, external connection implants (USII; Osstem, Busan, Korea) were installed in the mandibular left second premolar and first molar region. After removal of the existing implant prosthesis, a preliminary impression was taken to create a provisional restoration. Analysis of the mounted diagnostic casts at the current OVD revealed sufficient interocclusal space to establish an occlusal plane and to provide an adequate restoration space. Consequently, the diagnostic wax-up was performed at the current OVD placing the occlusal plane at the medial two thirds of the retromolar pad. Considering the diagnostic wax pattern, the remaining teeth were prepared, and a provisional prosthesis was placed after extraction of the mandibular right lateral incisor due to a poor prognosis. A cone beam computed tomography image was obtained to evaluate the implant installation site in the maxillary anterior region and mandibular right first premolar. Because the bone

Fig. 7. Evaluation of occlusal vertical dimension using the Willis method and the McGee method.

Fig. 8. (A) Facebow transfer, (B) Mounting procedure to semi-adjustable articulator.

Fig. 9. Reverse curve of Wilson due to excessive occlusal wear.
quality and quantity was favorable enough to achieve good primary stability, the position of the additional implant in the maxillary anterior region for the cross-arch splinting was chosen as the maxillary left incisor, and an internal connection implant (Superline; Dentium, Seoul, Korea) was installed to form natural emergence profile using soft tissue support. After confirming the primary stability of the implant, a provisional abutment was connected and splinted with the adjacent implants immediately using cross-arch fixed provisional restorations (Fig. 11). However, a two-stage surgical approach was performed in the mandibular right first premolar region because of a thin buccal plate requiring bone grafting.

On follow-up examination 2 months later, the peri-implant marginal bone level was maintained without noticeable changes. However, the provisional restoration showed changes of occlusal morphology resulting from excessive wear (Fig. 12). Consequently, an additional analysis was planned with regard to the TMJs as posterior controlling factors and masticatory movement.

No pathologic bony changes were observed on cone beam computed tomography images of the condylar heads and articular surfaces, but there were adaptive bony changes on the medial wall of the mandibular fossa, resulting in wide mandibular lateral translation movement (Fig. 13). Additionally, on analysis of masticatory movement using an ARCUSdigma II (KaVo Dental GmbH, Biberach, Germany), the patient demonstrated a wide grinding pattern and horizontal lateral translation movement of the condyles (Fig. 14). Consequently, re-evaluation of occlusal stability was planned with a second provisional restoration to correct the impaired occlusal morphology. During this procedure, customized abutments (Myplant, Raphabio C., Seoul, Korea) were created for the cement-retained implant prosthesis. Considering the wide mandibular lateral translation movement, the anterior guidance and posterior cusps were adjusted to achieve a flatter occlusal plane (Fig. 15). After placement of the provisional restoration, adaptation of esthetics and occlusion was evaluated during 6 weeks of application. The provisional restoration did not cause any noticeable changes in occlusal morphology or any discomfort. No mastication or pronunciation problems were found, so a definitive prosthesis was fabricated.

The pick-up impression was taken on the abutment level for the posterior teeth. On attaching the master casts to the articulator with a cross-mounting technique, anterior guidance of the provisional restoration was transferred. Full contour wax patterns were created on the master casts, and gold-alloy frameworks were made. The definitive prosthesis was placed and adjusted to achieve group function. After taking a definitive impression of the anterior region, the interocclusal record was taken using a recording base and the master casts were attached to the articulator with a cross-mounting technique. In order to reproduce the anterior guidance and contour of the provisional restoration and prevent porcelain chipping of the implant prosthesis, a double scanning technique was used and monolithic zirconia fixed dental prostheses (FDPs) were fabricated. The definitive prosthesis
Fig. 11. First provisional restorations. (A) Maxillary occlusal view. Immediate loading after implant installation of maxillary left incisor, (B) Right lateral view, (C) Frontal view, (D) Left lateral view, (E) Mandibular occlusal view.

Fig. 12. Occlusal morphology changes of provisional restoration after 2 months. (A) Curve of Spee, (B) Curve of Wilson.

Fig. 13. Adaptive bony changes on the medial wall of the mandibular fossa.
Fig. 14. Axiographic tracing in mastication by ARCUSdigma II. (A) Right TMJ, (B) Hinge axis movement, (C) Left TMJ, (D) Incisor edge in sagittal view, (E) Incisor edge in frontal view, (F) Incisor edge in horizontal view.

Fig. 15. Second provisional restorations with flatter occlusal plane.
was placed and adjusted to achieve group function (Fig. 16). One week later, a maxillary occlusal splint was placed and the patient was instructed to wear the occlusal splint at night. On follow-up examination at 2-week intervals for 3 months, oral hygiene was verified to be excellent, and there were no signs in problems with mastication, occlusion, esthetics, phonetics, or the TMJ. Also, the peri-implant marginal bone level was maintained without noticeable bone loss in periapical radiographs (Fig. 17).

Discussion

During full mouth rehabilitation, establishing the occlusal plane is an important factor for improving the prognosis of prostheses by forming an ideal occlusion that is compatible with functional movement of the stomatognathic system. The occlusal morphology forming the occlusal plane functions in harmony with the structures that control mandibular movement, and the critical structures involved in this are the TMJs and anterior teeth. Disharmonious relationships of the TMJs with the anterior guidance and posterior teeth may cause imbalance or hyperactivity of the masticatory muscles, and can eventually lead to pathologic tooth mobility, fractures, and excessive occlusal wear. The patient in this case had undergone full mouth rehabilitation 6 years earlier, but establishment of the occlusal plane was not compatible with the envelope of function, and this caused complications with the prosthesis and loss of teeth, requiring retreatment. Therefore, by reforming compatible relationships between the TMJs and the anterior guidance and posterior teeth, along with re-establishment of the occlusal plane, physiologic occlusion and masticatory function were restored.

The methods used to establish the occlusal plane differ for the anterior and posterior regions, and these two regions are generally evaluated separately. The vertical height of the occlusal plane in the anterior region is mainly determined based on esthetic requirements, with consideration given to exposure in the resting position and the smile, the curvature of the lower lip in a smile, phonetics, and the interpupillary line. However, researchers have differing opinions

Fig. 16. Definitive prosthesis showing harmonious occlusal relationship.
about the reference points for determining the occlusal plane in the posterior region, and the suggested reference points differ for the maxilla and mandible. The patient in this case was found to have a backward inclined occlusal plane based on assessment of the commissure of the mouth, hamular notch-incisive papilla, Frankfort horizontal plane, and retromolar pad. Ogawa et al.\textsuperscript{15,16} reported that if the occlusal plane is backward inclined, the anterior and lateral displacement of the incisor edges increases because of delayed seating of the nonworking side condyle in closing of the mandible, and a wide and gliding masticatory pattern is observed. The occlusal guidance is shallow in patients showing a wider lateral gliding masticatory pattern, and lowering the height of the posterior cusp is generally considered to avoid occlusal interference.\textsuperscript{16} Therefore, for this patient, it was thought that occlusal interference due to the backward inclined occlusal plane of the existing prosthesis could cause excessive occlusal wear, so re-establishment of the occlusal plane was planned.

The long-term stability of the posterior teeth depends on the anterior teeth not being worn or moving, and it is important to establish the anterior guidance so that it does not interfere with the neutral zone or envelope of function during movements of the mandible.\textsuperscript{5} However, if excessive wear is observed at the labio-incisal edges of the lower anterior teeth or the lingual surfaces of the upper anterior teeth, restriction of the envelope of function is one potential cause.\textsuperscript{5} In this patient, analysis of mandibular movement showed a horizontal condylar path and a wide gliding masticatory pattern, which are considered to be the result of adaptive changes of the TMJs. The worn lower anterior teeth were not corrected during the first prosthetic treatment, and a steepened anterior guidance was formed, limiting the envelope of function. As a result, movement of the mandible appeared to have become stronger in order to restore horizontal function, and this is thought to have caused additional wear of the anterior teeth that had not been restored and porcelain chipping of the implant prosthesis in the maxillary anterior region. Therefore, in the second prosthetic treatment, to establish a correct relationship between the incisor edges of the lower anterior teeth and the maxillary anterior teeth, which forms the anterior guidance, replacement of the existing prosthesis and prosthetic restoration of the mandibular anterior teeth were planned.

Since increasing anterior guidance angle may limit the existing envelope of function and cause parafunctional bruxing later, it is more appropriate, if possible, to form a posterior disclusion while not increasing the anterior guidance angle.\textsuperscript{6} Following 2 months of use of the first provisional restoration, for which a new occlusal plane was established and the anterior guidance angle was increased, changes in occlusal morphology were observed due to excessive wear of the posterior teeth. For restoration of the impaired occlusal morphology and re-evaluation of occlusal stability, a second provisional restoration was fabricated. To prevent tooth wear, the posterior cusp height was reduced while flattening the curvatures of the occlusal plane, and by applying a shallow anterior guidance, posterior disclusion was induced upon mandibular movement. On evaluation 6 weeks later, the morphology of the provisional restoration had been maintained, so the definitive prosthesis was constructed.

Provisional restoration duplication methods using digital scans and
computer-aided design/computer-aided manufacturing have recently become available for clinical application, and there have been reports of prostheses being constructed using these methods. In the present case, the esthetic shape of the provisional restoration and the lingual surfaces for anterior guidance were duplicated using a double scanning method, and these features were reflected in the definitive prosthesis which was fabricated using monolithic zirconia FDPs.

When changing the anterior guidance during prosthetic treatment, evaluation of changes in mandibular movement during mastication is necessary. A closing path located more anterior than the opening path is called a ‘protrusion pattern’ and may cause faceting of the anterior teeth and pathologic flaring. In the present case, when mandibular movement was evaluated using a ARCUSdigma II, we observed a path where the beginning and end of the mandibular movement were consistent, suggesting stable anterior guidance.

Despite full mouth rehabilitation in this patient 6 years earlier, establishment of an occlusal plane that was not in harmony with the envelope of function caused complications associated with the prosthesis. The prosthesis was reconstructed together with implant installation, and masticatory function was restored by re-establishing the occlusal plane and anterior guidance such that it was compatible with the envelope of function. Currently, the patient shows stable function, but periodic follow-up and maintenance therapy are required.

In summary, the patient in this case underwent full mouth rehabilitation 6 years earlier, but experienced complications of the prosthesis, which resulted in collapse of the occlusal plane and inappropriate anterior guidance. For this patient, the flat occlusal plane and the shallow anterior guidance were determined by the analysis of mandibular movement and using a provisional restoration, and these characteristics were reflected in the definitive prosthesis, which improved masticatory function.

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실패한 임플란트 보철수복물을 가진 환자의 교합평면 재설정

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계속적인 치아의 상실과 마모 및 보철물의 실패로 초래된 생리적 이상이란 교합평면은 비식미성, 저작 효율의 감소 및 교합 간섭과 같은 기능적인 문제를 야기할 수 있다. 따라서, 무치악 환자나 교합 평면이 봉괴된 환자의 보철 치료 시, 저작 기능과 조화로운 교합평면의 설정이 중요하다. 본 증례의 환자는 완전 무치악 상태인 상악을 임플란트 고정성 보철물로 수복하였다. 6년 간의 관찰 시, 기존 임플란트 보철물의 도제 파열, 마모, 나사풀림과 같은 기계적 합병증이 관찰되었고, 대합하는 전치의 마모 및 정품과 일부 구치부 치아의 상실로 인해 교합평면이 봉괴된 상태였다. 진단 과정을 거쳐 무치악 부위의 추가적인 임플란트 식립과 보철물의 재제작 및 모든 잔존 치아의 수복을 통해 전악구강회복을 시행하였다. (대한치과보철학회지 2018;56:141-53)

주요단어: 교합평면; 전악구강회복; 전방유도

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